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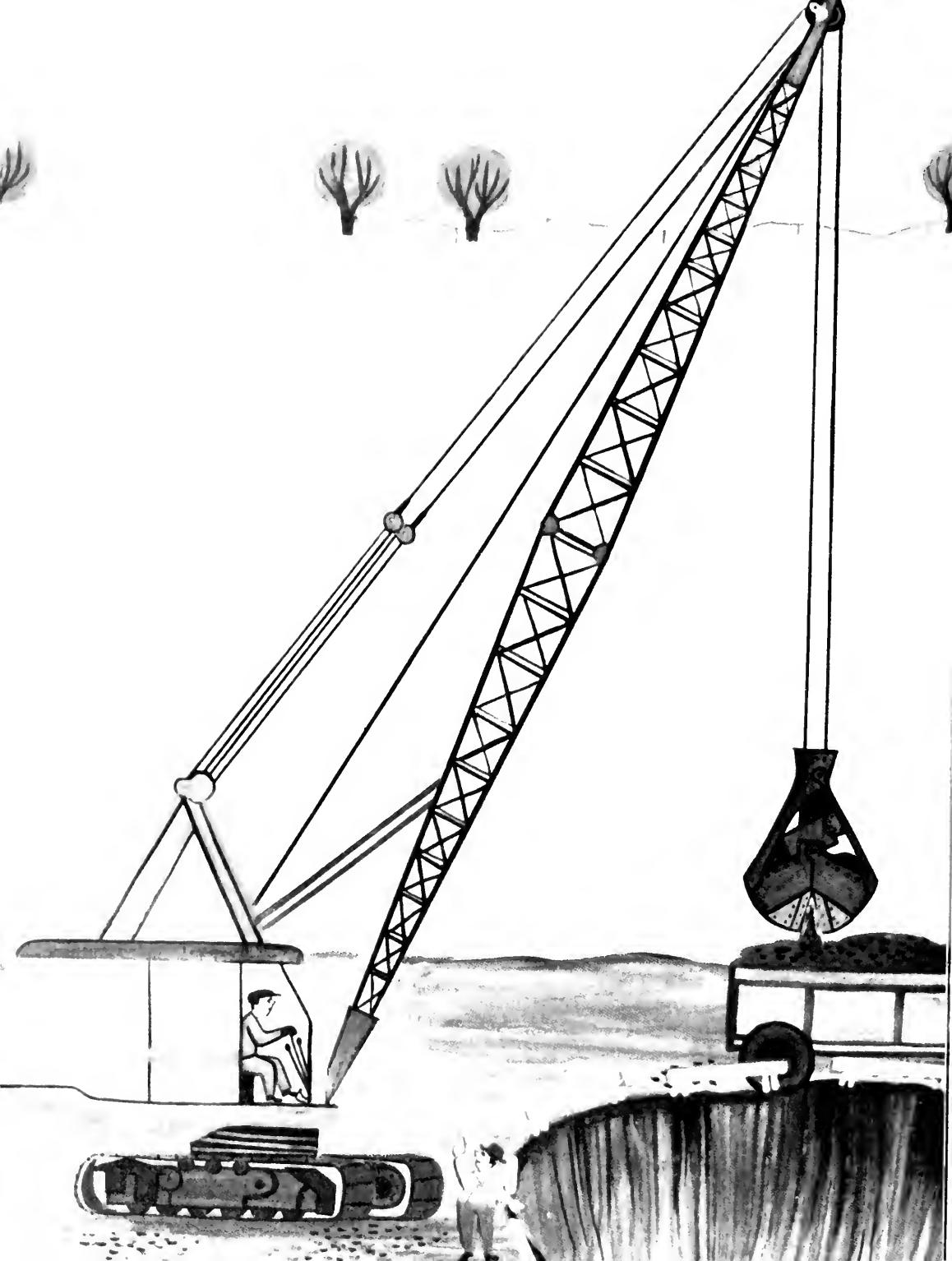


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MACHINES AT WORK





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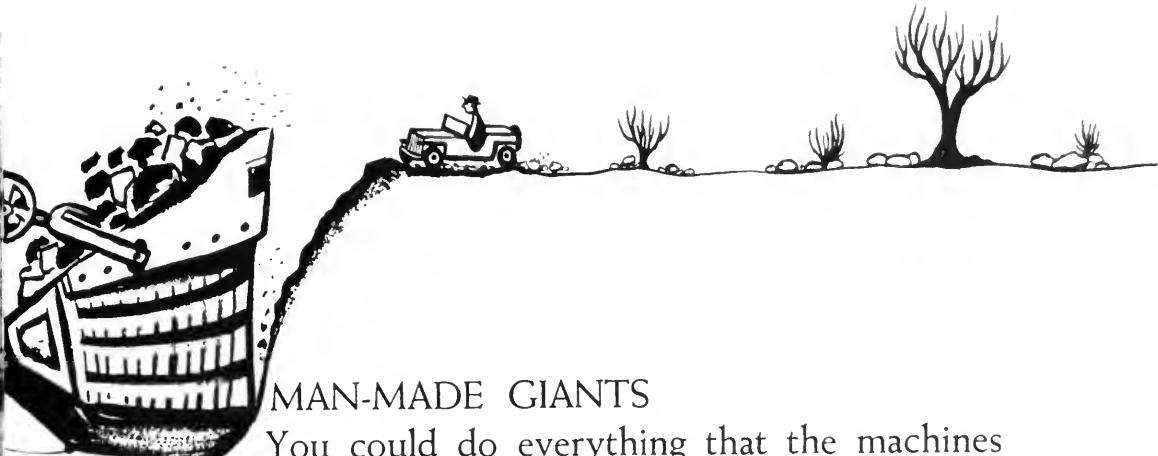
By Mary Elting



ILLUSTRATED BY
LASZLO ROTH

GARDEN CITY BOOKS GARDEN CITY, N.Y.





MAN-MADE GIANTS

You could do everything that the machines in this book do. For some of the jobs, of course, you'd have to get friends to help you. But people have always been able to work and build wonderful things, using just their muscles. And they can do a very great deal more when they use their brains, too. They can invent machines to make work thousands of times easier and faster.

The big machine in the picture is a shovel that's used for digging an enormous hole. In one bite, its scoop can tear out a chunk of earth more than twice as tall as a man. Its long arm, called the boom, lifts the load as high as the top of a seven story building, then swings around and drops it almost a city block away.

There are only a few shovels like this in the world. They were especially made to work where beds of coal lie close to the surface of the earth, covered by a layer of soil. The shovels clear away the soil so that other machines can dig out the coal.



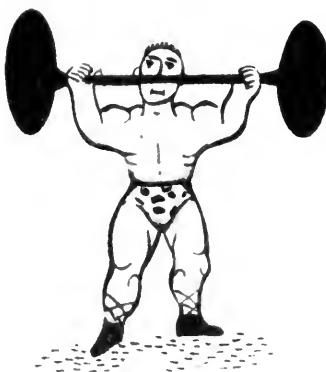
When a giant shovel has cleared off one spot, its crawlers begin to turn, and it creeps slowly ahead. But it can't travel on roads. It's far too big and heavy and tall — so big, in fact, that it came to the mine in separate pieces. Forty-five freight cars were needed to haul all the parts for just one machine from the factory to the mine. Then experts put the parts together right where the shovel was to start digging.

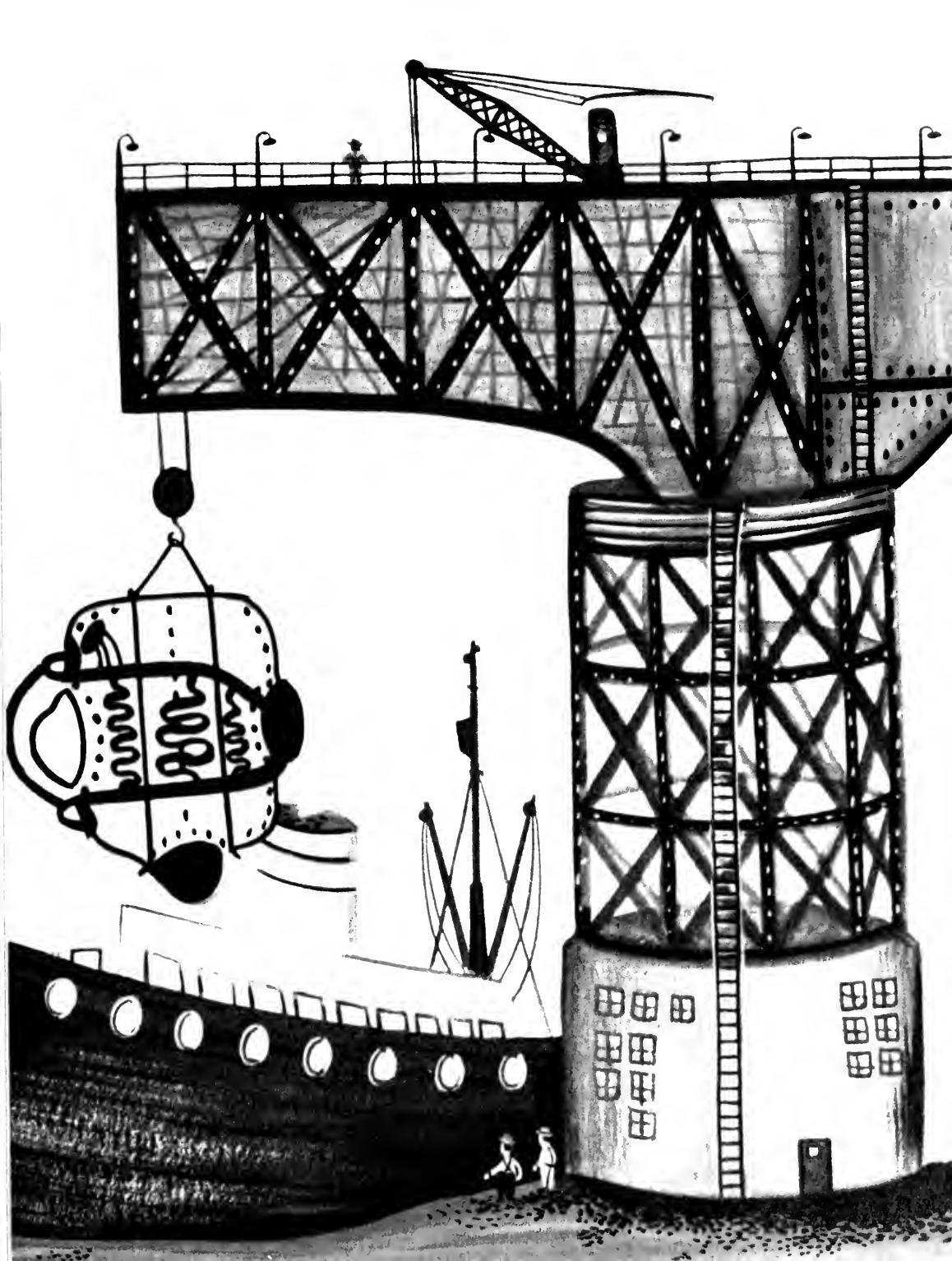
And dig it does. In one minute its scoop can bite out as much dirt as 3,600 men could dig just using their muscles to lift ordinary hand shovels!

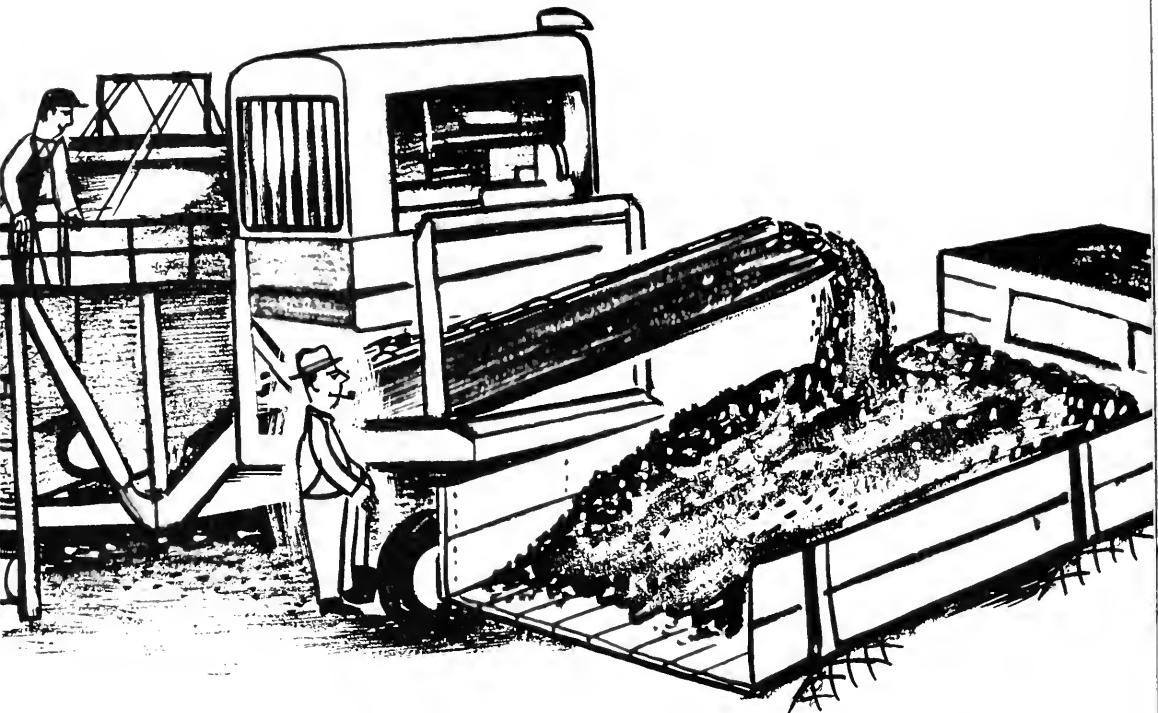
The giant shovel is one of the biggest machines ever made, but there's another that can lift even bulkier things. It is an overhead crane that works in a shipyard.

Often the crane hoists big boilers out of ships so that repair men can work on them. It is so huge that it carries another crane on its back. The piggy-back crane — that's its real name — reaches down and lifts things off the deck of the ship, too.

Hammering is another kind of muscle work that



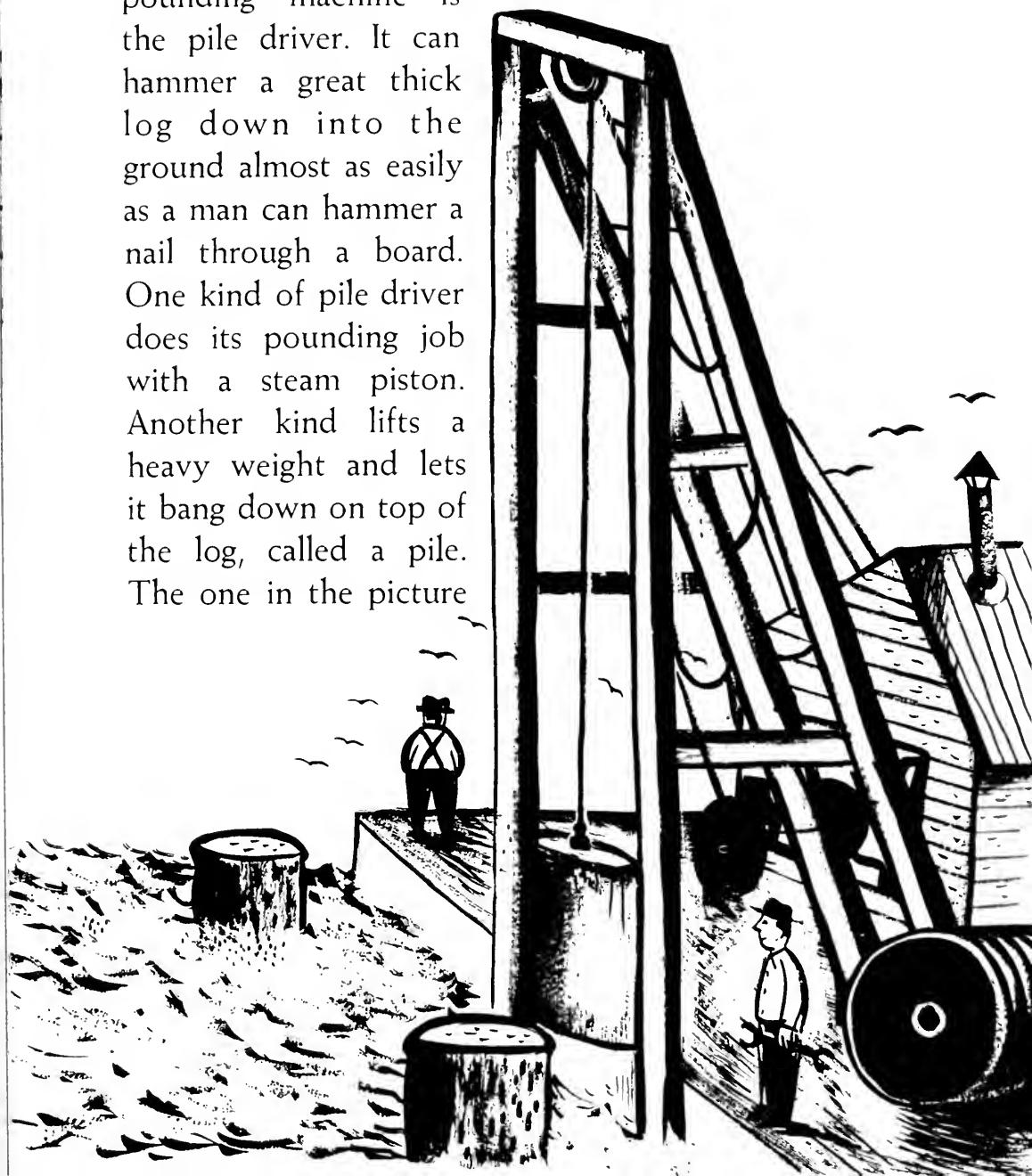




machines can do quickly and easily. Suppose the water pipes under your street need mending. Repair men have to tear up the pavement in order to reach the pipes. So they bring in jack hammers to do the pounding. Strong blasts of air run the hammers, and, in no time, the pavement is broken up.

Crushed rock was used for making the paved street in the first place. It came from a big machine called a rock crusher, which breaks up chunks of stone into small pieces. Strong jaws inside the crusher chew at the stone until they have made it into bits that are just the right size.

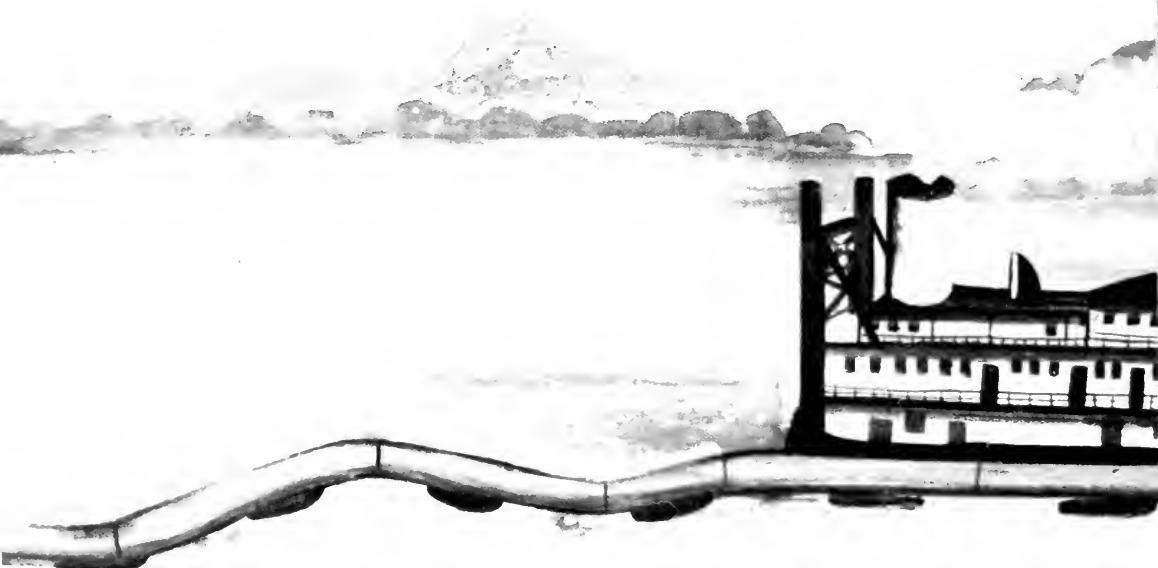
An even bigger pounding machine is the pile driver. It can hammer a great thick log down into the ground almost as easily as a man can hammer a nail through a board. One kind of pile driver does its pounding job with a steam piston. Another kind lifts a heavy weight and lets it bang down on top of the log, called a pile. The one in the picture



works in a harbor. It drives piles deep into the earth that lies under water. A whole group of piles make the foundation for a pier in the harbor, for ships to tie up alongside.

Harbors and rivers must be kept safe for ships. If mud and sand pile up in a thick layer on the bottom, ships may get stuck. So dredges go to work clearing the mud and sand away. Often a clean-up job takes a long time. The men who run the machinery live on board the dredge, just as sailors live on a ship.

Some dredges have scoops that dig under water. Others, like the one in the picture, use giant suction pumps. The mud or sand they suck up is called spoil.

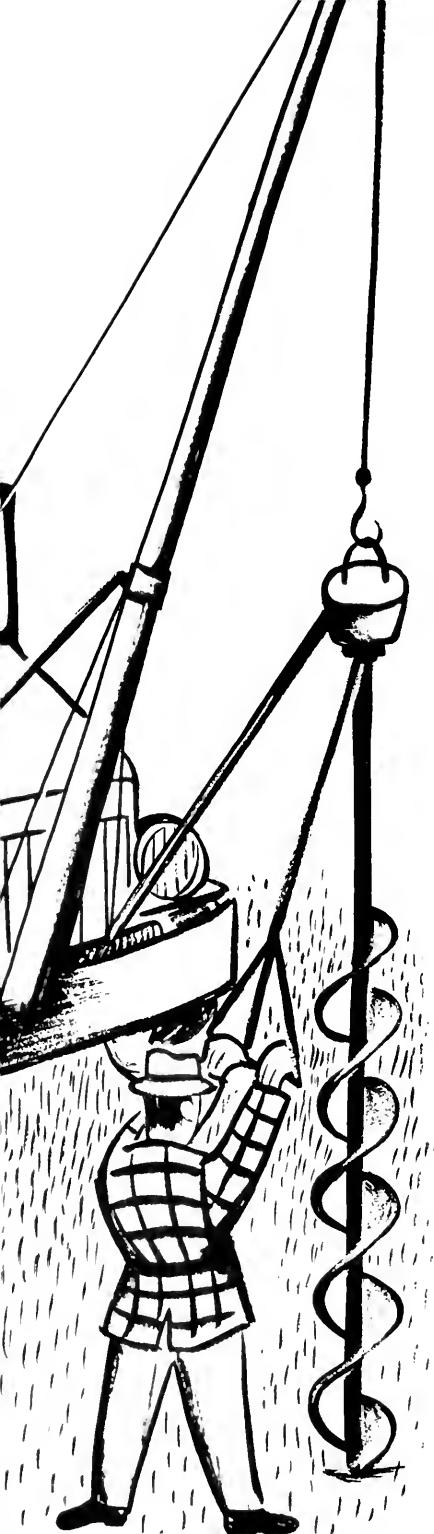


If there's hard-caked mud on the bottom, cutter heads break it up. Then it's ready to be pumped out through huge steel pipes that stretch away from the dredge like a great snake and pour the spoil out on land.

Of course, a dredge must stay in one place while it is working. So it carries along two huge spikes called spuds. These move straight up and down at the stern of the dredge. When they ram into the earth underwater, they keep the dredge from drifting.

A spud is so heavy that it pokes its own hole in the muddy bottom of a river or harbor. But making holes on dry land is a different problem. For instance, you can't just poke a telephone pole into the hard ground,





or pound it in easily with a pile driver, either. So, in many places, a machine bores holes for telephone poles, just the way a carpenter bores a hole with a brace and bit. Then the machine's long arms reach out, lift a pole into the air and plug it down neatly into place.

Long ago our ancestors discovered how to use simple tools — such as hammers, shovels, crowbars and rollers. These things seem very ordinary to us, but they were really wonderful discoveries. The clever men who invented them were providing ideas, one by one, which scientists and engineers used much later. Our great machines are combinations of many, many things that men discovered from using simple tools.

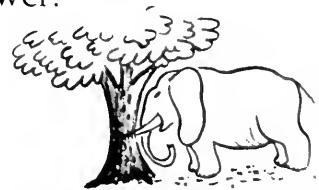


POWERFUL PUSHERS

The giant shovel digs; the overhead crane lifts; the pile driver pounds. All machines multiply the power that's in the muscles of men — or of animals. The pushingest animal is an elephant. In some places in the world, elephants are trained to clear land by putting their foreheads against a tree and heaving until the tree topples over.

A tree-dozer can out-push an elephant. The one in the picture has a special forehead built in front. With a slow, steady shove, it clears the way for roads or opens up fields for farms.

Farmers used to dig their fields by hand. Then they hitched horses to plows. Now a tractor does the work, but we still measure its strength in horsepower.



MACHINES FOR FARMERS

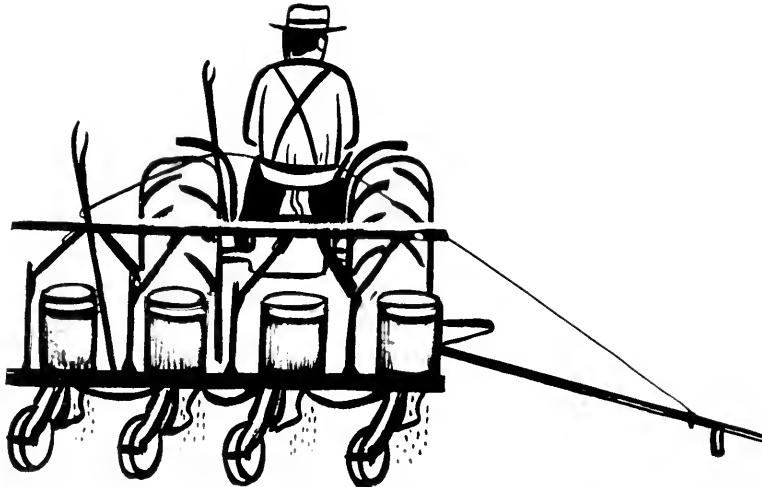
Dan is a farmer. He knows how to use almost any kind of farm machine, and he has lots of them. The most important is his tractor, for it is busy all year round. Sometimes it pushes. Sometimes it pulls. Or it may stand still and lend its power to other machinery.

When the frost is out of the soil in the spring, Dan backs his tractor into the tool shed and bolts on a plow. This one is a two-gang plow — it can make two furrows in the earth at the same time. Dan touches a lever. The blades of the plow lift up so they can't dig into the farmyard and the road, and Dan chugs off to the field. Another touch on the lever sends the blades down. In a few minutes, Dan has made the first furrows across the field.

Now he has to turn. He lifts the plow and steps on the left brake pedal. While the big left wheel stands still, the right one keeps going and turns the tractor, ready to start the next furrows. When Dan wants to stop, he steps on both the left and right brake pedals at once.

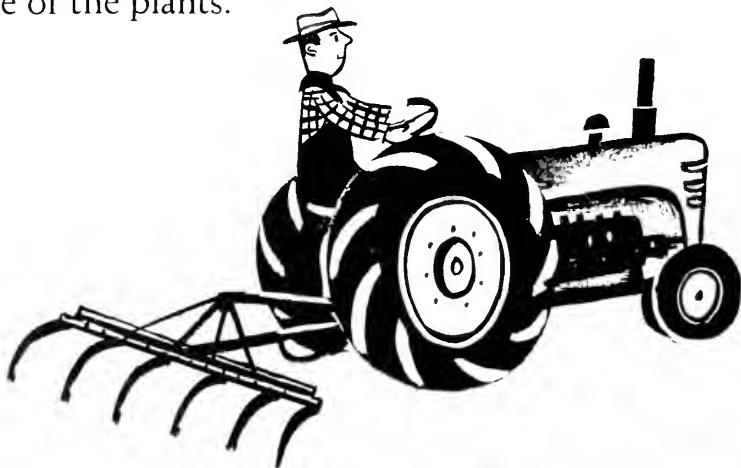
After plowing comes harrowing. The tractor pulls a different implement for this job — a whole row of saucer-shaped metal discs that chew up the soil and spread it out evenly. Now Dan is ready to plant corn.

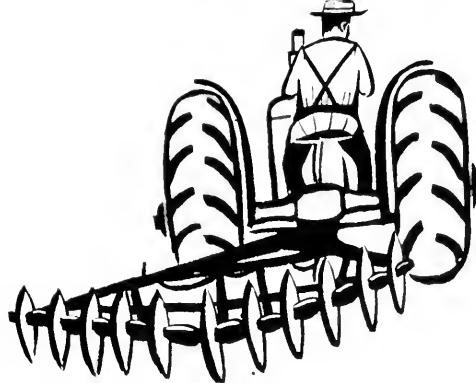




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The corn planter does five jobs in one trip down the field. It makes trenches for two rows of corn. It drops corn seeds into the trenches. It drops fertilizer alongside to give food to the young plants. It covers the seeds. And it leaves a mark all along the field to show exactly where the tractor should go to plant the next row of seeds. Dan follows the mark very carefully. All the rows must be exactly the same distance apart, because the tractor will have to go through the field again to cut out the weeds after the corn starts to grow. If the rows are badly spaced, the tractor wheels will squash some of the plants.





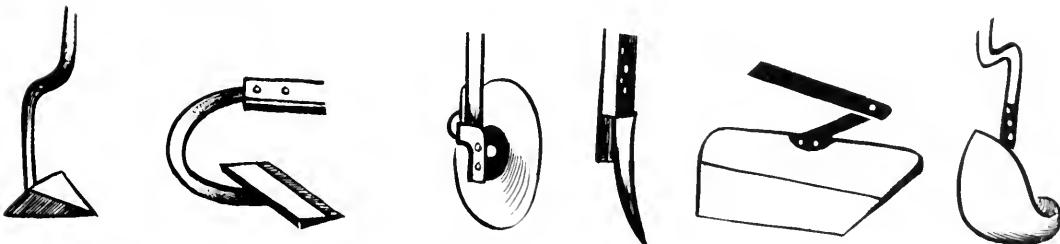
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When Dan was a little boy, he used to help his father hoe the corn by hand, getting rid of weeds and loosening the soil. Now he has an implement called a cultivator which does the job.

After the corn is well up, Dan pulls the cultivator through the field, driving carefully, with the wheels between the rows. Small blades on the cultivator cut through the weeds and break the soil into loose chunks. The pictures show several kinds of cultivator blades.

All summer long the corn grows tall. Dan waits till the ears are dry before he harvests them, ready for his cows and chickens to eat in winter.

Dan's farm is small, so he can't afford to buy a big corn-picking machine. But his neighbor Al has one that he rents out, and one morning Dan drives it to his



cornfield. His tractor seems lost inside the picking machine. Gatherers that look like the pointed snouts of huge mice creep along in front of the tractor close to the ground. One by one the stalks of corn go into the machine, which snaps the ears off. Then revolving claws and rubber paddles rip off the husks, and an elevator carries the clean ears back to a wagon which the tractor pulls along. In a very short time, Dan's whole field is done.

Corn isn't the only thing that grows on Dan's farm. He raises tomatoes for the market, too. At planting time, he needs two helpers who ride on little seats very close to the ground behind the tractor. They put the tender little tomato plants one by one into a trench which the planting machine digs, and then a special wheel covers the roots with earth.

Dan has some wheat fields, too. In the spring, after the ground is harrowed, a wide planting machine sows many rows of wheat at a time. And it drops out fertilizer to feed the plants on the same trip.

Many farmers use their tractors for harvesting wheat, but Dan doesn't. Instead, he rents a shiny red

reaper which he calls a "package job," because it moves itself along and does the whole harvesting at once. It cuts the wheat, shakes the grain loose from the stalk and separates it from the husks. If there are weeds growing in the wheat, the machine separates the weed seeds from the wheat kernels and spills them into different bags.

Dan sits high in the air at the front of the machine. He says he has a "box seat." Behind him on a bench sits



a helper who ties the bags as they fill up and puts new bags in place. Dan says it won't be long before somebody invents a machine that will reap the wheat, grind the flour and bake bread right there in the field!

All of Dan's machines are wonderful inventions, but they can be dangerous, too, if people are careless. To give himself and his helpers warning, he has painted bright stripes and markers around open places where fingers might get caught in moving parts.

EGGS, TOO

Dan has a flock of fine white Leghorn chickens. He takes care of them by machinery, for eggs are a crop, too. The hens live in cages with wire floors, so that they keep very clean. All their droppings go through the wire to a platform below. With a special scoop, run by his tractor, Dan cleans the manure from the platform and puts it in a pile to be used as fertilizer on the fields.

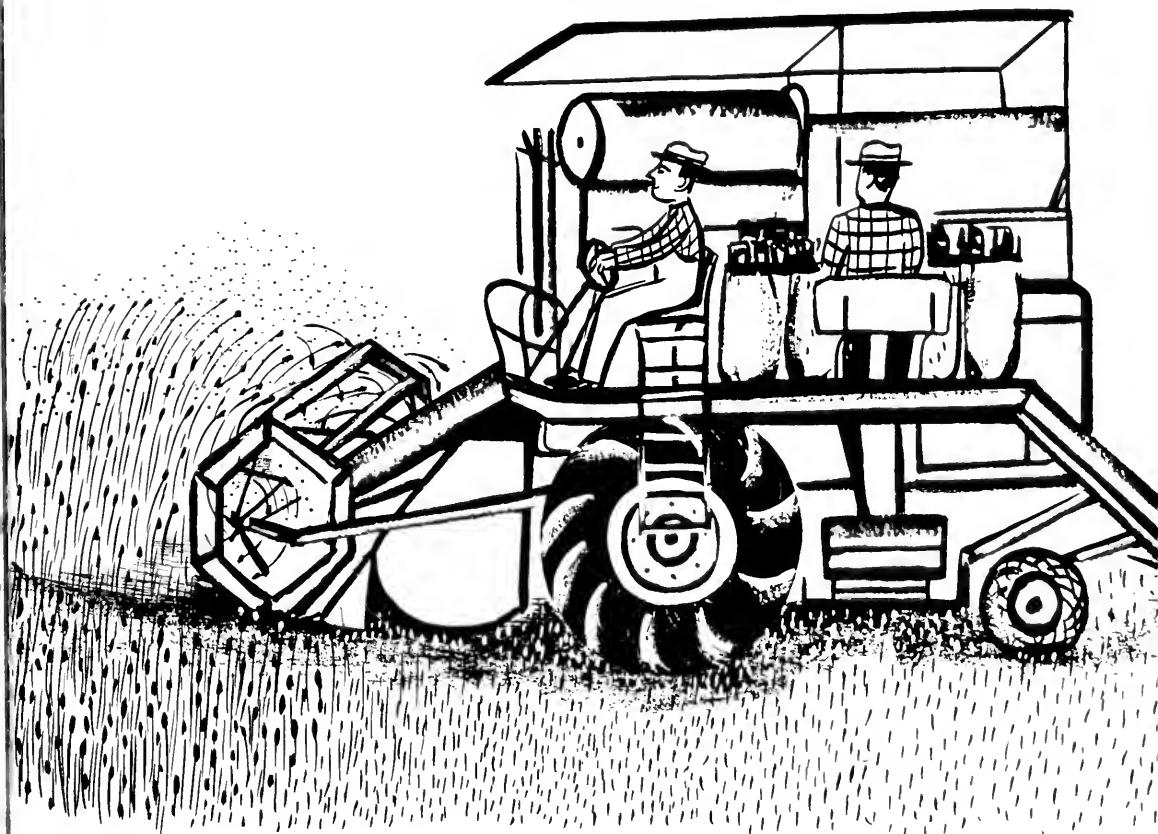
Every day the chickens have their meals brought to them on a moving belt. The eggs they lay drop through their nests onto another belt that carries them away. Finally a machine sorts the eggs according to size, ready for packing.

Some farmers raise chickens for the market. Of course, the feathers must be taken off after the chickens have been killed. There are machines for this, too. One

kind has mechanical fingers that pluck the feathers as chickens go past on a moving belt.

MACHINES FOR BIGGER FARMS

Dan's neighbor Al has a big dairy farm, with lots of cows to milk every day, and land enough to grow their feed. Besides his corn picker, Al has other special machines. One of them cuts corn while it is still green, chops it up fine and loads it into a truck. The truck has a sort of cage over it to keep the corn from spilling out. Next, Al turns his tractor into a stationary engine which

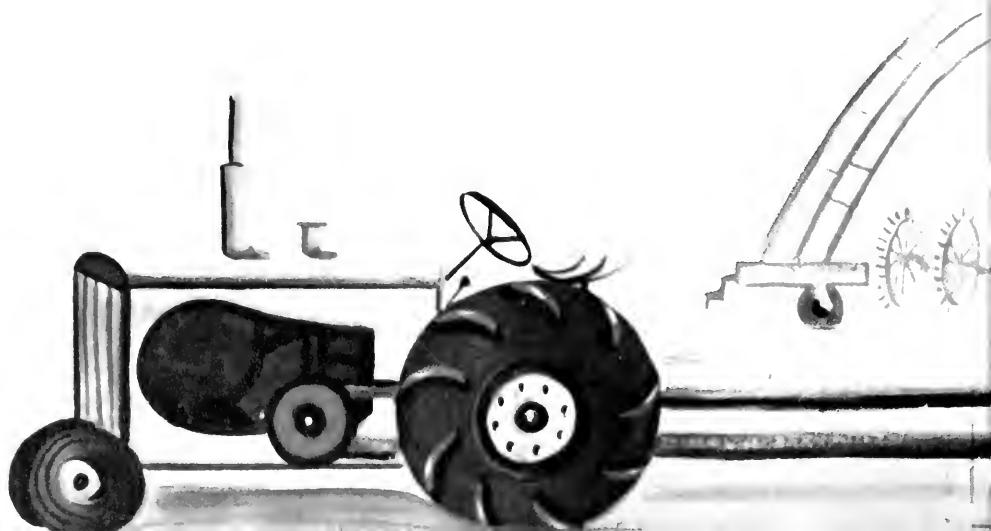


runs a blowing machine. A wide belt from a pulley on the tractor turns the blower, which shoots the chopped-up corn to the top of a storage tower called a silo. The green stuff ferments in the silo and turns into wonderful food for the cows.

Al's fields are so big that he needs larger plows than the one Dan uses. He hires an airplane to spread dust that kills plant-eating insects.

Al plants his hayfields with a seeding machine that he pulls behind the tractor. Grass seed is so tiny that it can't be planted deep. Al's seeder sprinkles just the right amount of seed on the soil, and then squeezes a thin covering of earth on top. He says the machine "tucks each seed to bed."

After the mowing machine has cut the hay, Al pulls his automatic baler across the field. The baler scoops the hay up, then presses it into a box-shaped bundle,

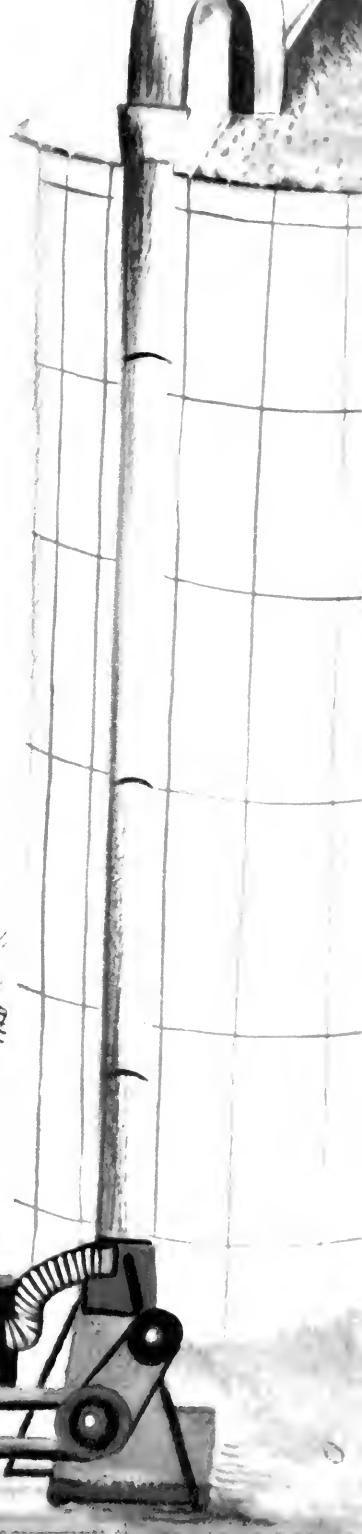


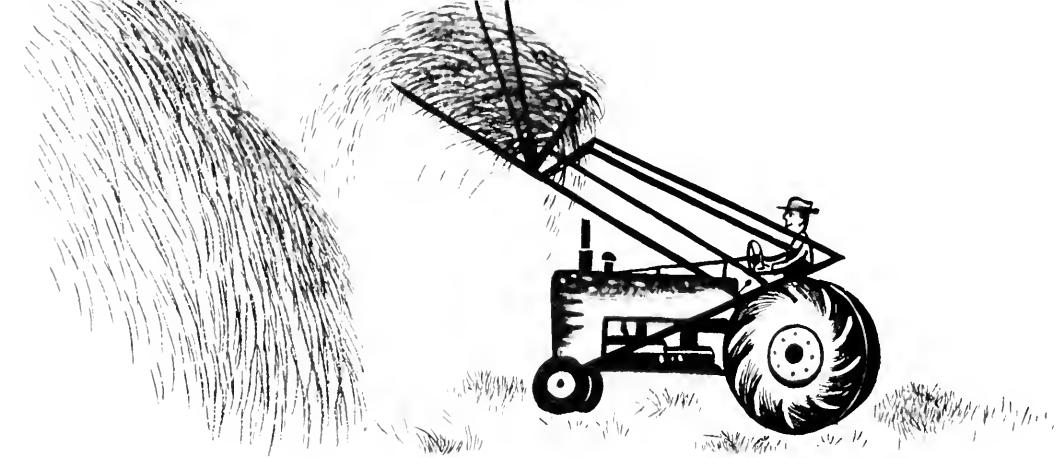
slices it off neat and square, and ties it with strong twine. One by one the bales drop out on the field, ready for a truck to pick them up.

Some farmers rake their hay into long heaps called windrows before they bale it. The machine that does this job has many teeth that whirl round and push the hay sidewise into the windrows. The whole field has a rolling look, like ocean waves.

The hay must be dry before it goes into the barn. If it isn't, it may get moldy. And green hay may even be dangerous. It can actually make heat enough to start a fire.

To be sure his hay keeps well, Al

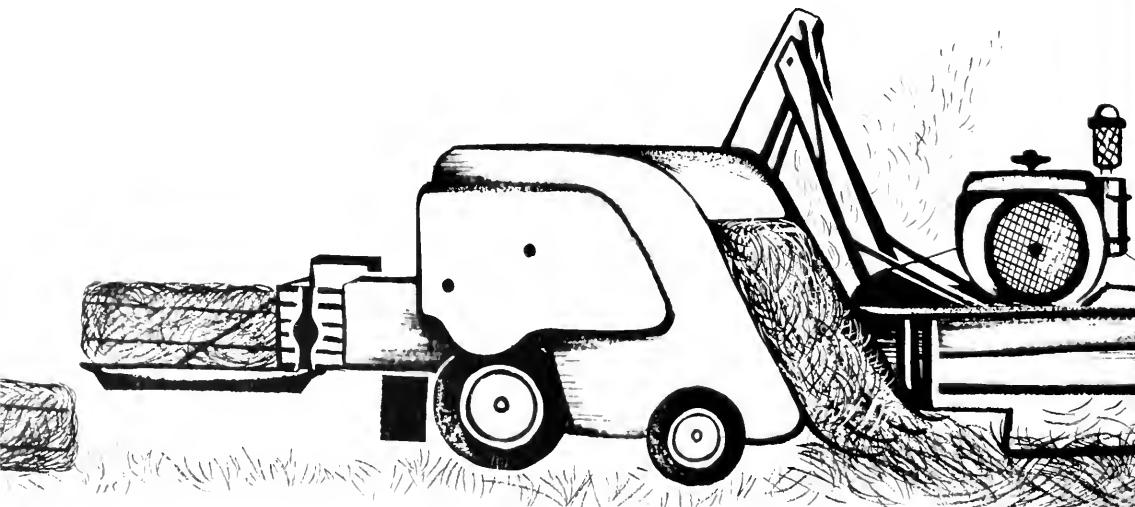




has a blower that circulates air around the barn and dries the bales completely.

Some farmers use machines that tie the hay into round bales. Others don't bale it at all. They use stackers to pile it into tall stacks where it is kept till the cows are ready to eat it.

The stacker fits onto the tractor. When it was first invented, farmers thought it was a sort of luxury, be-



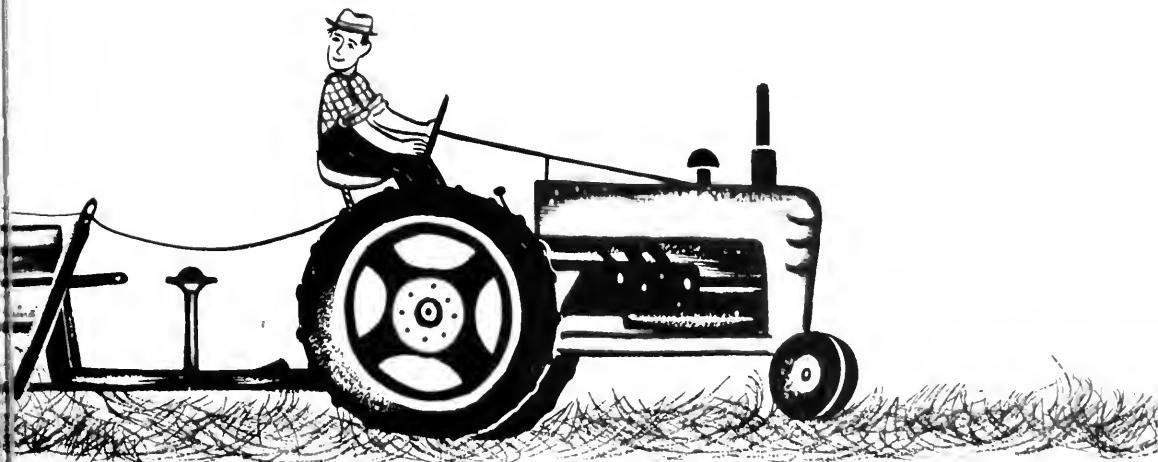
cause it was used so seldom. Then they discovered that they could put it to work on other jobs, too. If a platform of boards is fitted across the forks of the stacker, it turns into an elevator that a man can stand on. Then he can paint the barn or pick apples from high branches without having to climb up and down ladders.

MILKING MACHINES

It would take a lot of work to milk all of Al's cows. So he uses milking machines. When a man milks a cow, he squeezes with his fingers. Instead of fingers, the milking machine has four soft rubber funnels that fit over the cow's teats. A pump squeezes the funnels, presses the milk out and sends it through hoses to the milk can.

A farmer has only two hands. His milking machine has four funnels with hoses. So it can work much faster, and he can have several machines going at once.

You'd never guess it, but a cow is a nervous, fussy animal. She lets down her milk easily if the same per-



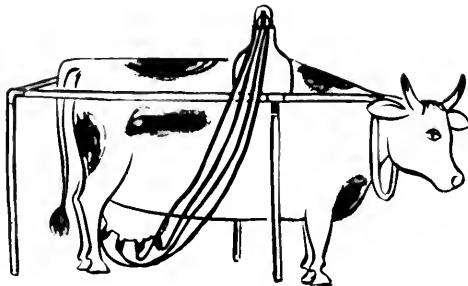
son or the same machine squeezes on her teats with the same rhythm every day, but any kind of change or hurry upsets her. Then she's hard to milk. And so Al's machine is built with a very accurate timer which makes the funnels squeeze exactly forty-eight times a minute.

A good farmer tries to make life calm and comfortable for his cows. Even the names for some things in Al's barn have a comfortable sound. The place where the cows wait to be milked is called the loafing pen. The room where they stand for milking is kept perfectly clean, and it's called the milking parlor.

Before the machine is attached, the cows' udders and teats must be washed clean. Al has fixed an upside-down shower bath for his cows. He built a concrete pen with sprays coming up through the floor. The showers clean the cows and make them feel so calm that he never has any trouble milking them.

The fanciest milking parlor of all has a machine in it called a Rotolactor. It is really a quiet, slow merry-go-round. Cows amble up a ramp and step into stalls on the gently moving platform. A man attaches milking machines to them, one after the other. By the time each cow has been carried halfway around the big circle, her milk has been pumped out into a glass tank that sits on a rack above her. A man takes off the rubber cups, a





gate opens in front of the cow, and she steps off onto another ramp that goes from the center of the merry-go-round, underneath it and out to the barnyard. Twenty-five cows at a time can be milked on the Rotolactor.

Automatic gadgets empty the milk from the glass tanks, wash them, sterilize them and get them ready for the next round. All the time men are busy keeping the stalls clean and tending to the machinery. Most dairies milk the cows twice a day, but the Rotolactor milks three times.

MACHINES FOR EVERY JOB

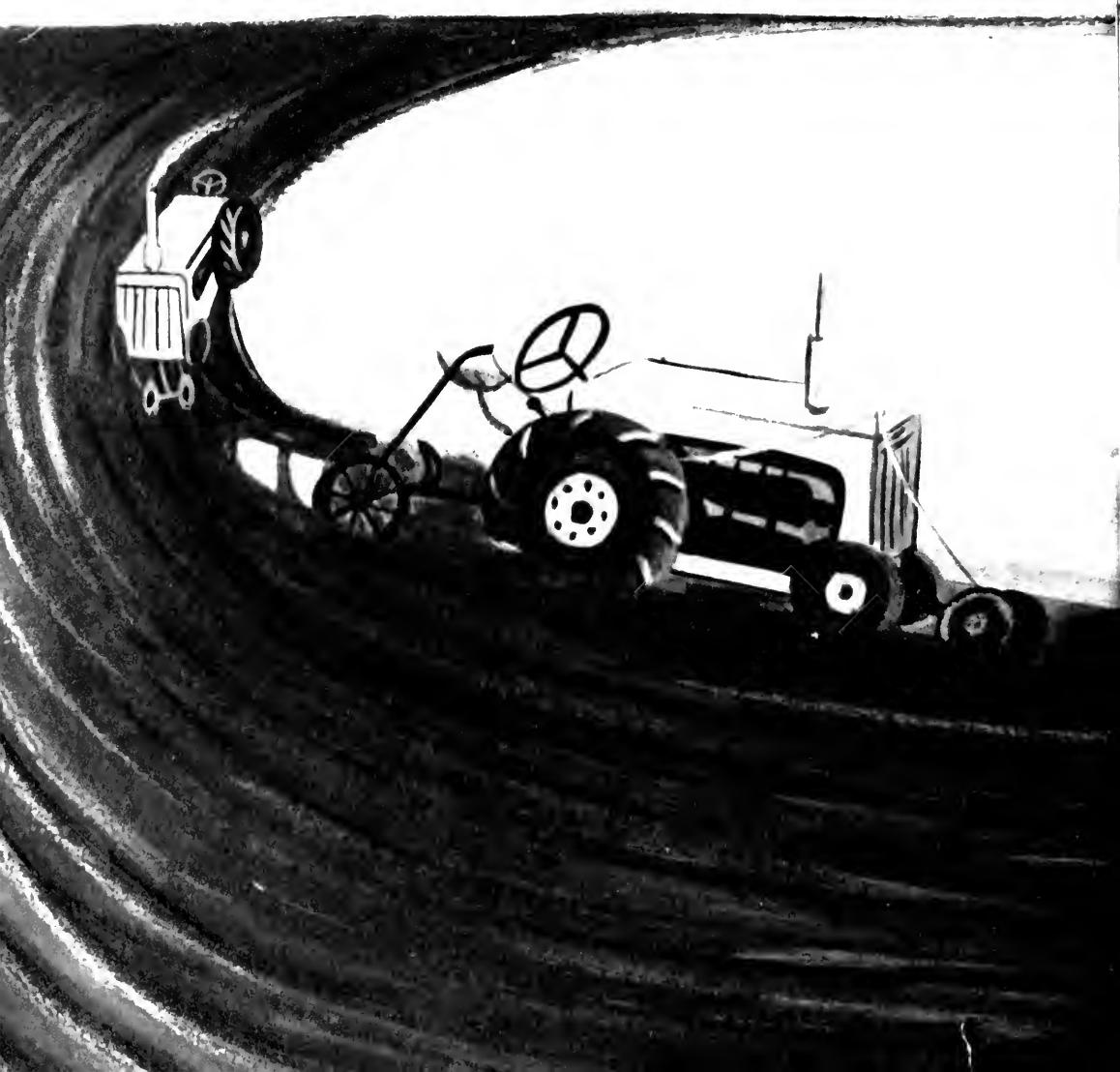
The Rotolactor was invented for one particular kind of huge dairy. But farmers everywhere like to have good machinery to do special jobs.

For hilly country, there's a plow that has one of its blades higher than the other so it can work on a slope. There are chisel plows that dig up hard soil by clawing at it with strong steel fingers.

One farmer in Texas decided to make his tractor do the plowing all by itself, after he had driven it once around the field to give it a start. He invented a guide



wheel that went ahead of the tractor in the furrow he had made. Now the guide led the tractor around in a spiral that got narrower and narrower until at last it stopped in the center of the plowed field. Another



Texan, with a bigger field and more machines, had a larger idea. He set three tractors loose without drivers, one behind the other. Away they went, round and round. If one traveled too fast and caught up with the



one ahead, they stopped. The only work he had to do was go out and start them up again!

There have even been experiments in guiding plows by remote control radio, the way airplanes can be guided. The farmer just sits under a tree and pushes buttons in a control box.

COTTON MEANS HARD WORK

Cotton is a crop that has always taken an enormous amount of work. Even after cultivating machines were invented, men had to go through the fields twice every year and hoe out weeds around the plants by hand. One farmer rigged up a contraption that made hoeing





easier. He hitched an air compressor to his tractor and ran hoses from the compressor to four special hoes. Then the escaping air jiggled the hoes in the men's hands and saved the work of swinging them up and down.

Nowadays some of the big cotton farmers have an easier way of solving the problem. They just keep the weeds from growing in the first place. As the planting machine drops the cotton seeds, it spreads weed killer along each side of the row. This killer is a particular kind of chemical that keeps the weeds from sprouting, but it does not hurt the cotton. The only weeds that grow in the field come up between rows where it's easy for a cultivator to scratch them under.

At cotton picking time, machines now do the work

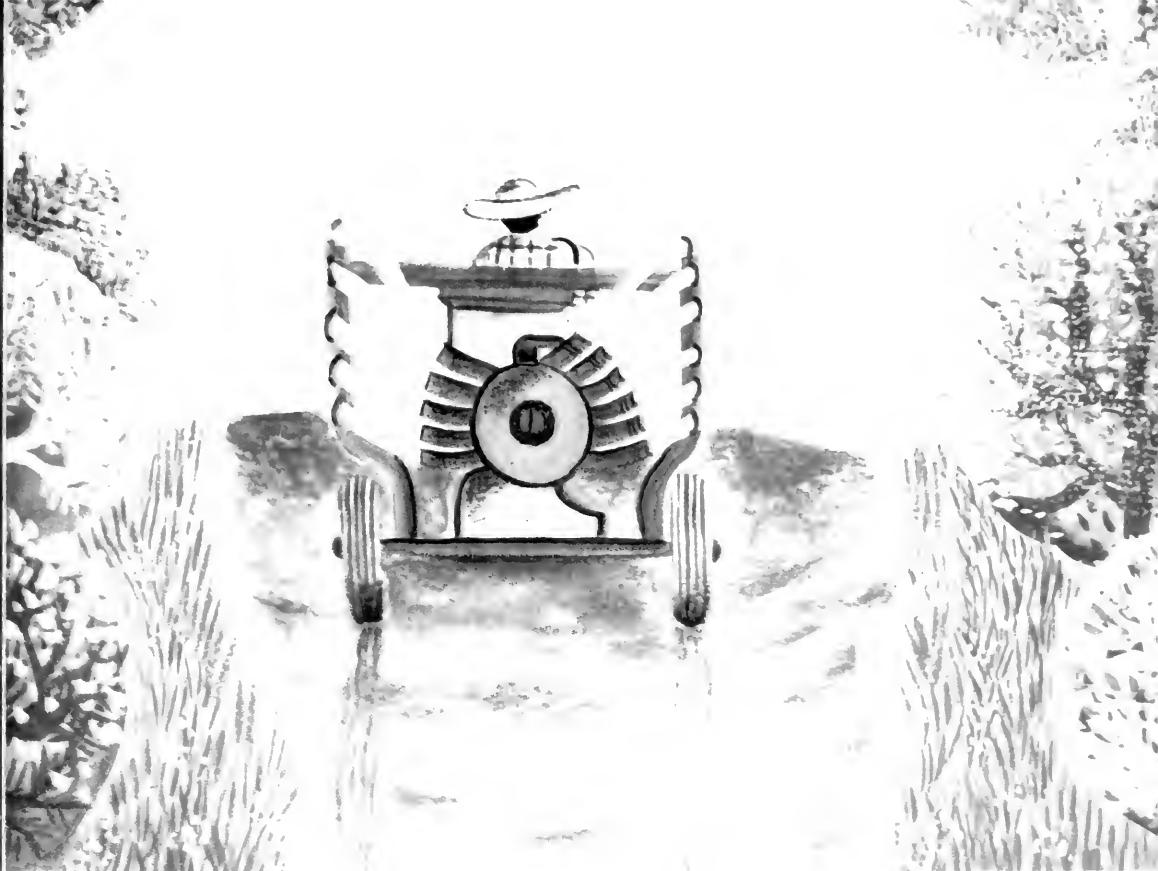
in many places. Cotton is ready to pick when the little round heads of white fluff called bolls break open. Not all the bolls on one plant burst at the same time. A man who picks by hand can tell by looking which ones are ready. Of course the machine doesn't have eyes, but its tiny barbed steel fingers catch up only the opened bolls. The fingers are fixed on a turning drum. They pluck the cotton from the plant, carry it around to be pulled off and blown through a big pipe into a large basket behind the driver.

People have been trying for at least a hundred years to invent a perfect cotton picker, and they haven't succeeded yet. The machines still can't do as careful a job as skilled men and women can do by hand.

SPRAYING MACHINES

Nobody could possibly do by hand all of the spraying that protects farmers' crops. Mechanical sprayers come in many shapes and sizes. The most usual sort for big fields travels along behind a tractor, shooting chemicals out from nozzles in a pipe that is twenty or thirty or even sixty feet wide.

Some of the special sprayers are queer looking machines. One of them has six squirmy arms, bent in different directions so that they get the chemicals underneath leaves and on top as well. The kind that sprays



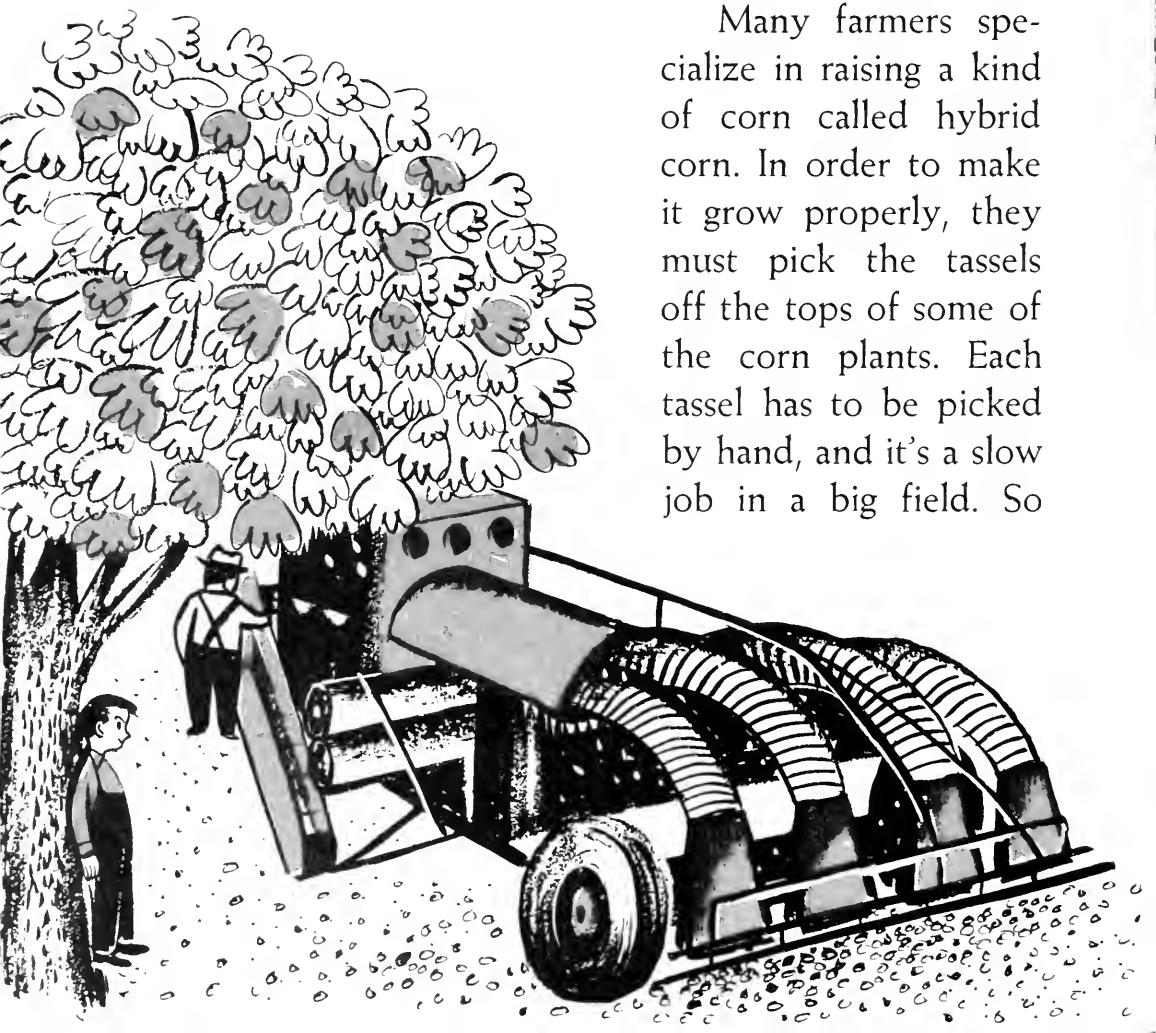
fruit trees pumps chemicals out of twelve pipes at once. It works so hard and fast that farmers call it a cyclone.

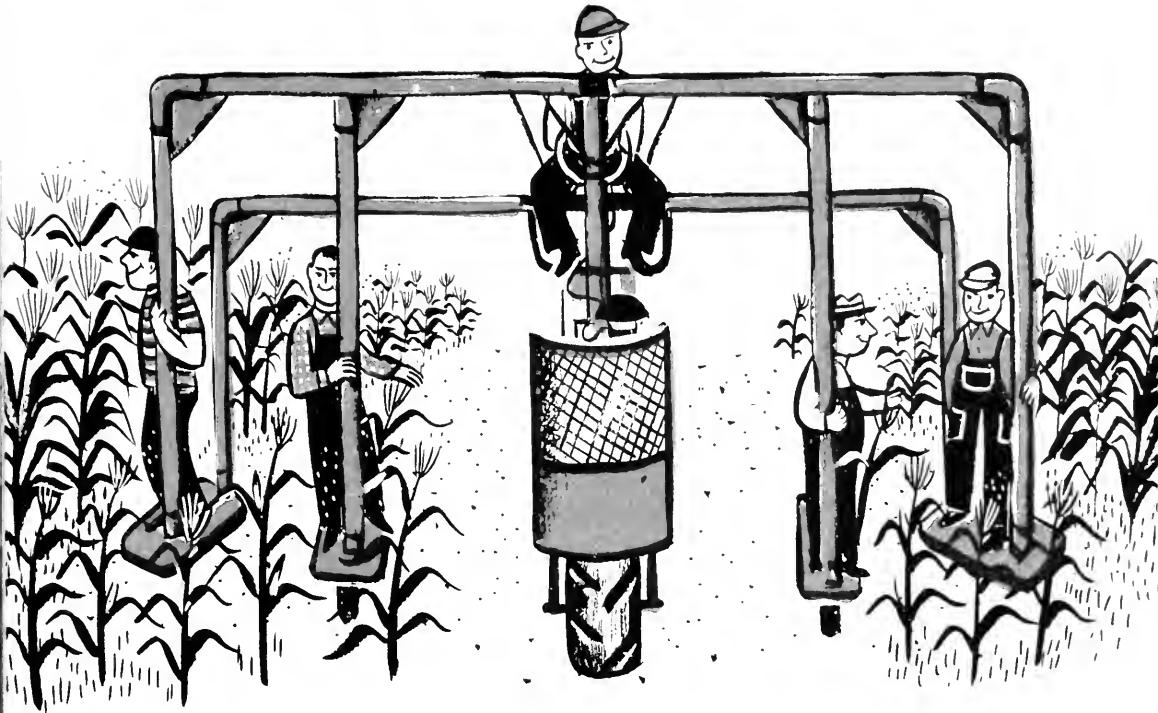
Then there is a sprayer that can be used for several different kinds of job. One day the farmer hitches it up to a tank near cattle pens. As the cattle walk down a narrow path between two fences, he sprays them with a chemical that kills bothersome insects. Next day, he may want to paint his fence. So he rigs the machine up differently and shoots paint onto the boards.

HOME WORK

All of this sounds as if everything that a farmer could need must have been invented by now. The fact is that there are new inventions coming along all the time, and farmers themselves make many of them. Every day in the week some farmer is likely to think up something he needs, then go to work making it. Here is a sample:

Many farmers specialize in raising a kind of corn called hybrid corn. In order to make it grow properly, they must pick the tassels off the tops of some of the corn plants. Each tassel has to be picked by hand, and it's a slow job in a big field. So





one farmer rigged up a machine that gives four tassel-pickers a comfortable ride all at the same time, and it gets the job done much more than four times as fast as before.

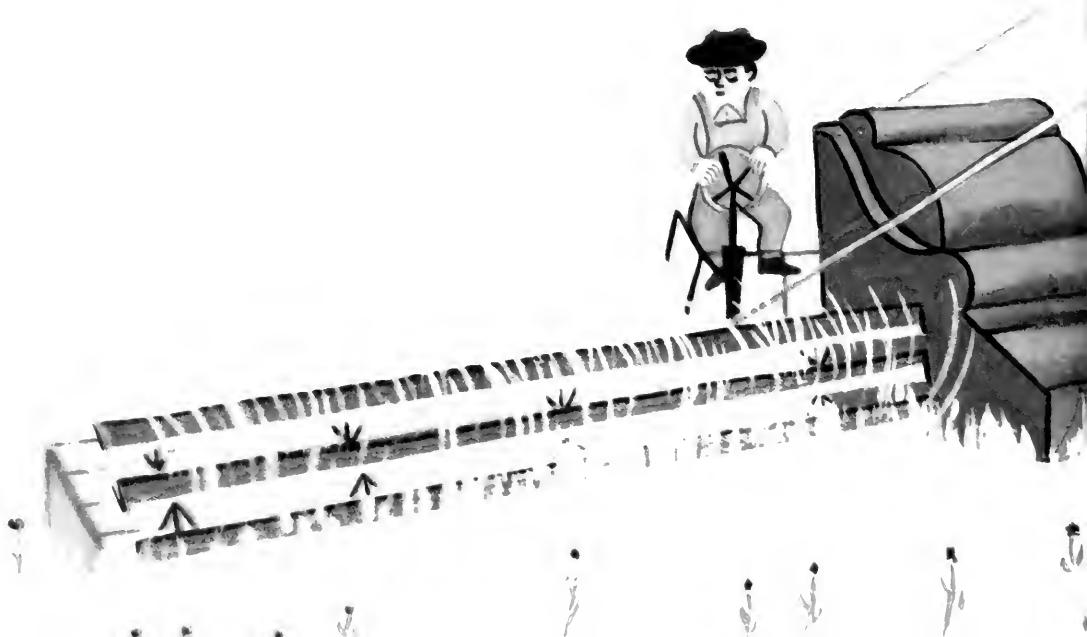
WONDERFUL INVENTIONS

It would take a whole book just to list the other machines that help different kinds of farmers. But here are some that are fun to know about:

One clever contraption attached to a tractor grabs hold of nut trees and gives them a hard shaking. The nuts fall on the ground, ready for a kind of giant vacuum sweeper to come and suck them into a truck.

Crops that grow underneath the earth need their own sort of harvesting machine. There are potato diggers and many others. The sugar beet digger works in a particularly clever way. Machine fingers feel for the beet tops. They set off a knife which cuts the tops off while other fingers lift the beet out and put it on an elevator which removes the clods of dirt as it travels. Once in a while the machine makes a mistake and delivers a stone or a chunk of mud at the end of the elevator. Men do nothing but throw the junk away and let the beets slide into the truck that travels alongside.

A farmer always has to keep an eye on what his implements are doing, unless he has a helper who rides along on machines like this big reaper. When the trac-





tor pulls a cultivator or a planter, the driver must turn his head often to see how the work is going. For a long time, farmers complained that this was a pain in the neck, and they really meant that their necks hurt from turning so much. Some of them actually went back to using horses, because they could either walk or sit behind horse-drawn machines. So the farm machine makers had to change as many of the machines as they could, placing them beside the tractor or out in front where the driver can watch what is going on.

Tractors themselves come in many sizes and shapes. Some are built very high off the ground so they can pass over tall crops without hurting the plants. Some have four wheels that can be pushed close together for work in one field and pulled wide apart for work in another. Some have three wheels.

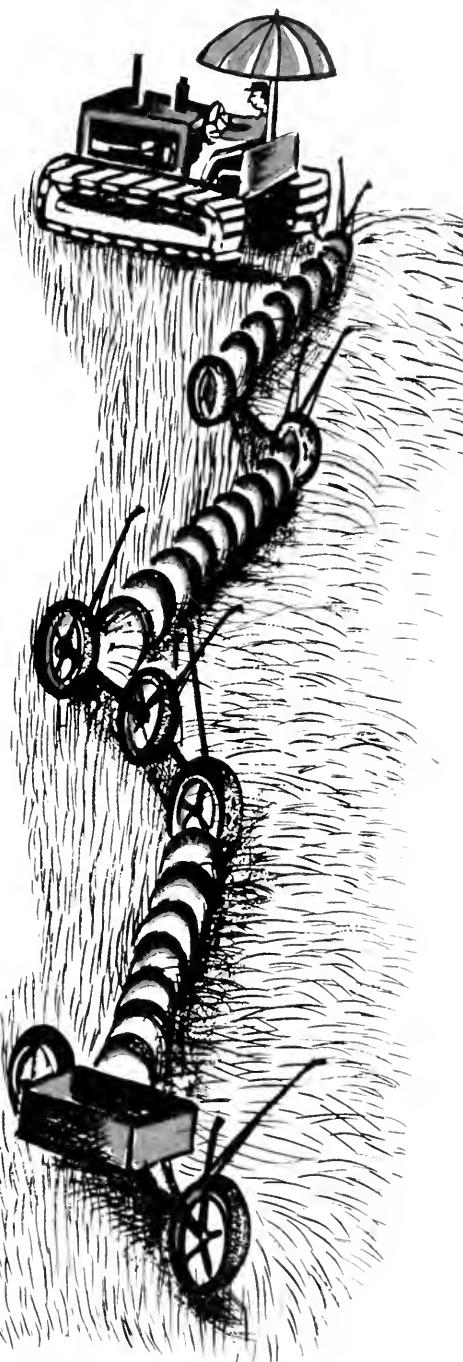
Mostly, farmers buy tractors the way people buy automobiles. They pick a model they happen to like and then argue that it's the best in the world. Of course, a little light "cub" tractor is easier to handle than a big one, but it can't do the hard work of a heavy model with huge rear wheels and tires. And here's something about the tires — farmers often fill them with water instead of air to give them more weight when they grip the ground. In winter, these farmers must put anti-

freeze not only in the radiator but in the tires as well!

On enormous farms where very heavy work must be done, there are often crawler tractors to do it. Instead of tires they have caterpillar treads that give a better grip on the ground. Then they can pull a whole string of plows the way you see them in the picture, staggered out behind.

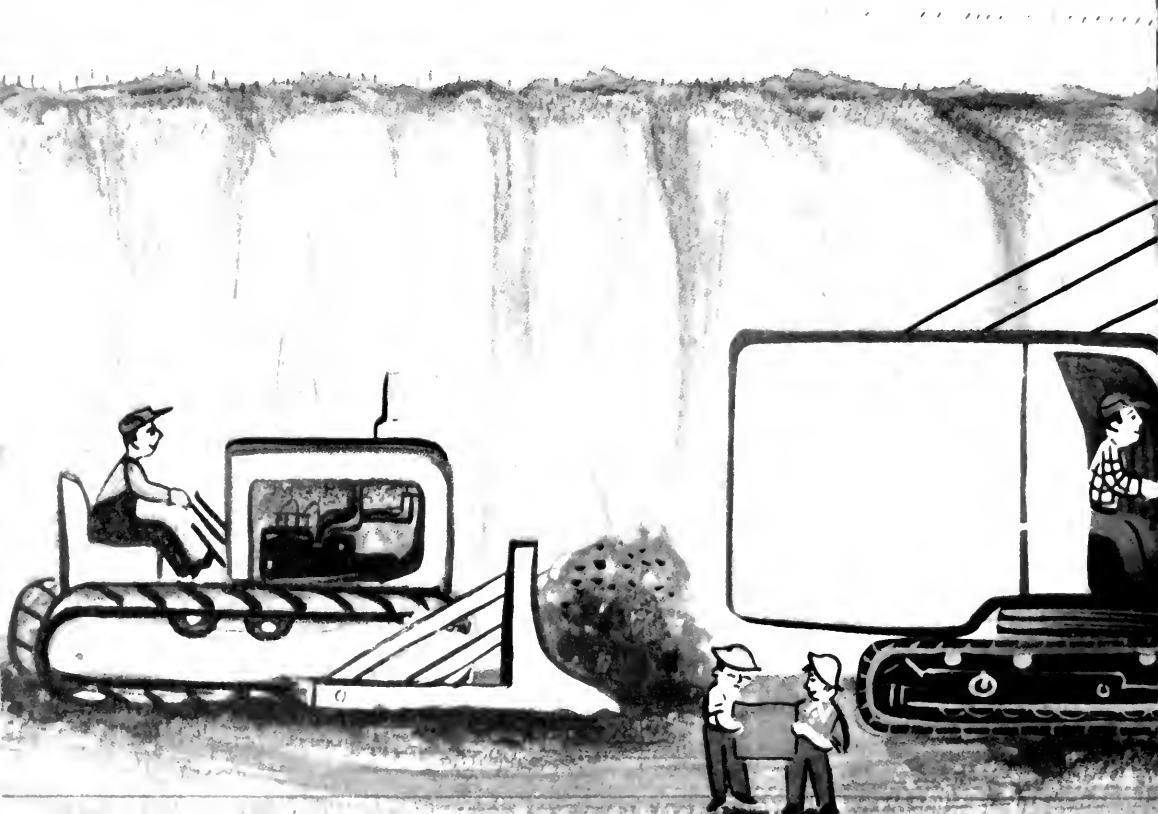
This kind of tractor was first named caterpillar by only one manufacturer. But people liked the idea, and they began to call all crawlers caterpillars.

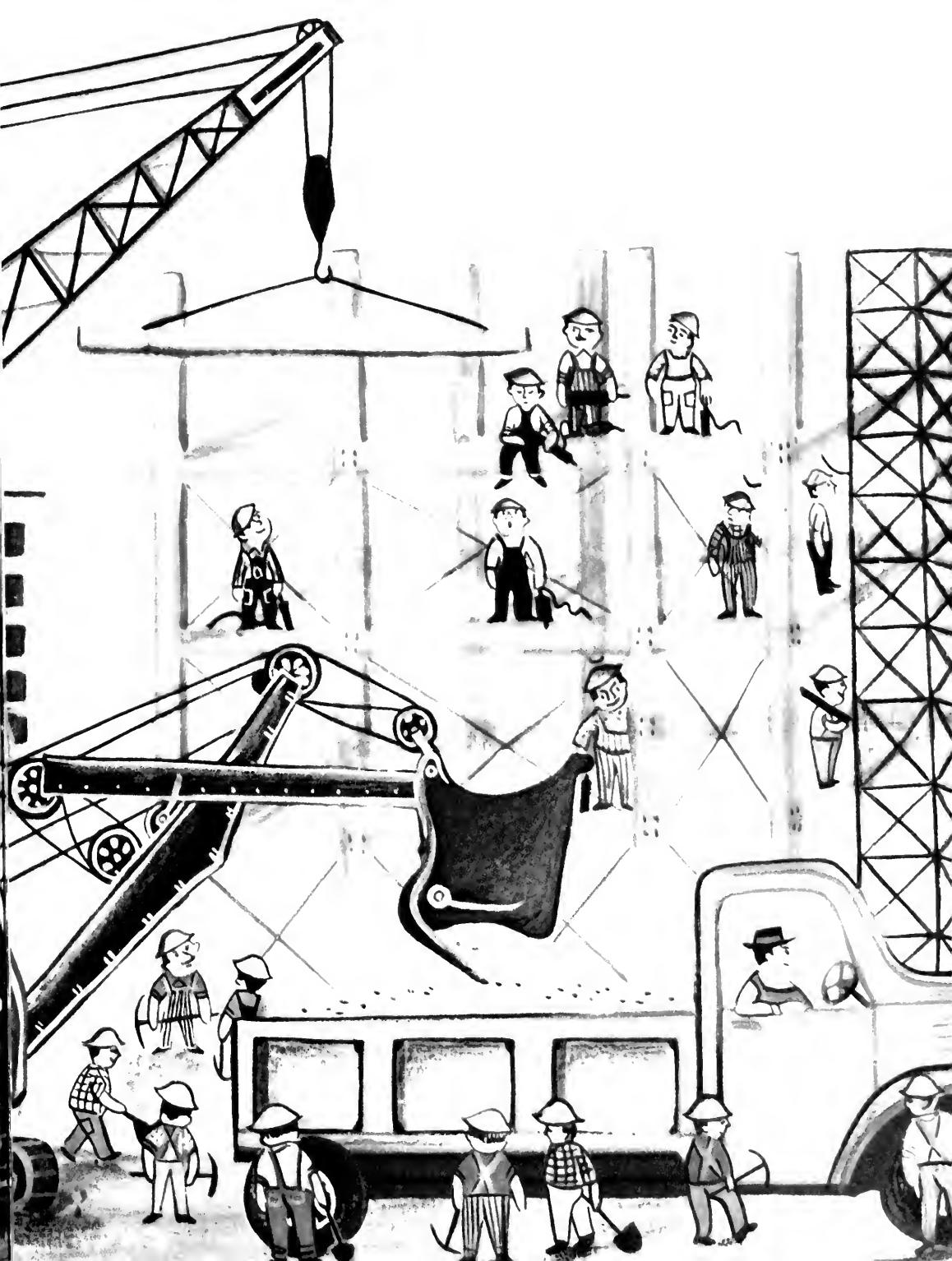
A caterpillar is powerful enough to push a snow plow, too. Or it can bulldoze out a hole for a watering pond or a cellar for a new building.

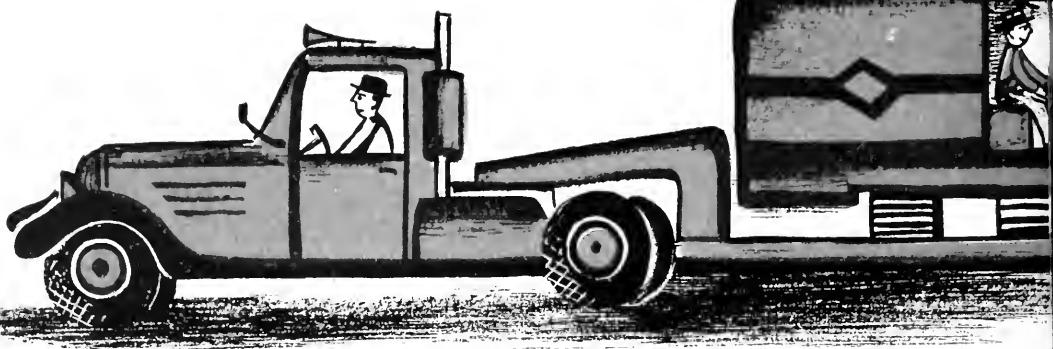


BUILDING MACHINES

Charlie is the man who can tell you about driving a caterpillar tractor. He works in a city, helping to put up big buildings, and he knows how to use other construction machines, too. In fact, Charlie grew up with machines, for his father and his uncles and his grandfather were construction workers. It often happens that families pass along their knowledge of building from the older to the younger men, and they are very proud of their skills. Charlie uses the caterpillar tractor with a bulldozer blade to push heaps of earth and rock into a pile, ready for the shovel to load on a truck.



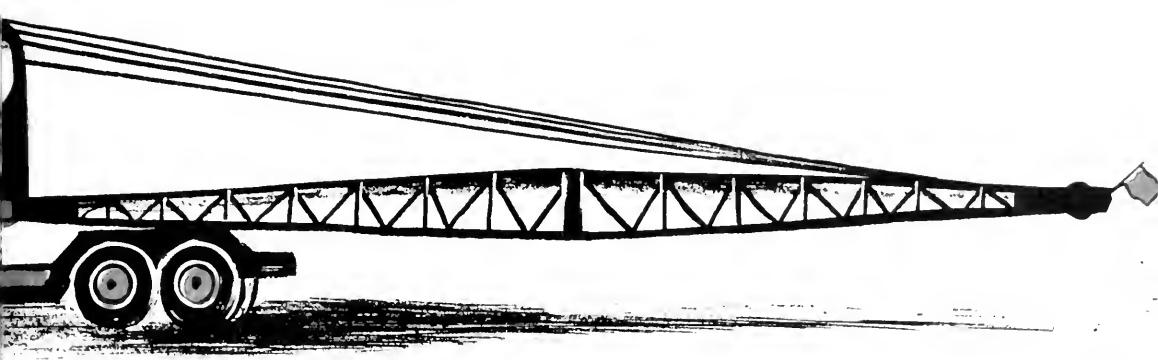




People often call the shovel a "steam shovel," but that's not its right name. You hardly ever see a real steam shovel any more. Years ago the big digging machines were driven by regular steam engines. Before they could start to work on a job, the men had to build a fire in the boiler and wait until they had enough steam pressure to make the shovel go. Of course, this wasted a lot of time. So, when very strong gasoline and Diesel engines came along, builders began using them for their shovels instead of steam engines.

Many shovels and other construction machines ride to work on long gooseneck trailers. They travel faster that way than they could on their own crawlers. And, in cities, the caterpillar treads might damage the pavement. To load and unload a shovel, the operator sets a short ramp of heavy planks against the trailer. Then the shovel creeps up and down on its own crawlers.

The kind of shovel that's used on a job depends upon the work that must be done. If a basement has to



be dug through hard rocky earth, Charlie may operate a crowd shovel, which crawls down into the hole. The shovel has a heavy dipper with teeth along the rim. When it digs, it crowds its teeth down into the ground. Charlie, sitting inside the cab, called the house, swings the dipper outward and up, then dumps the load into a truck.

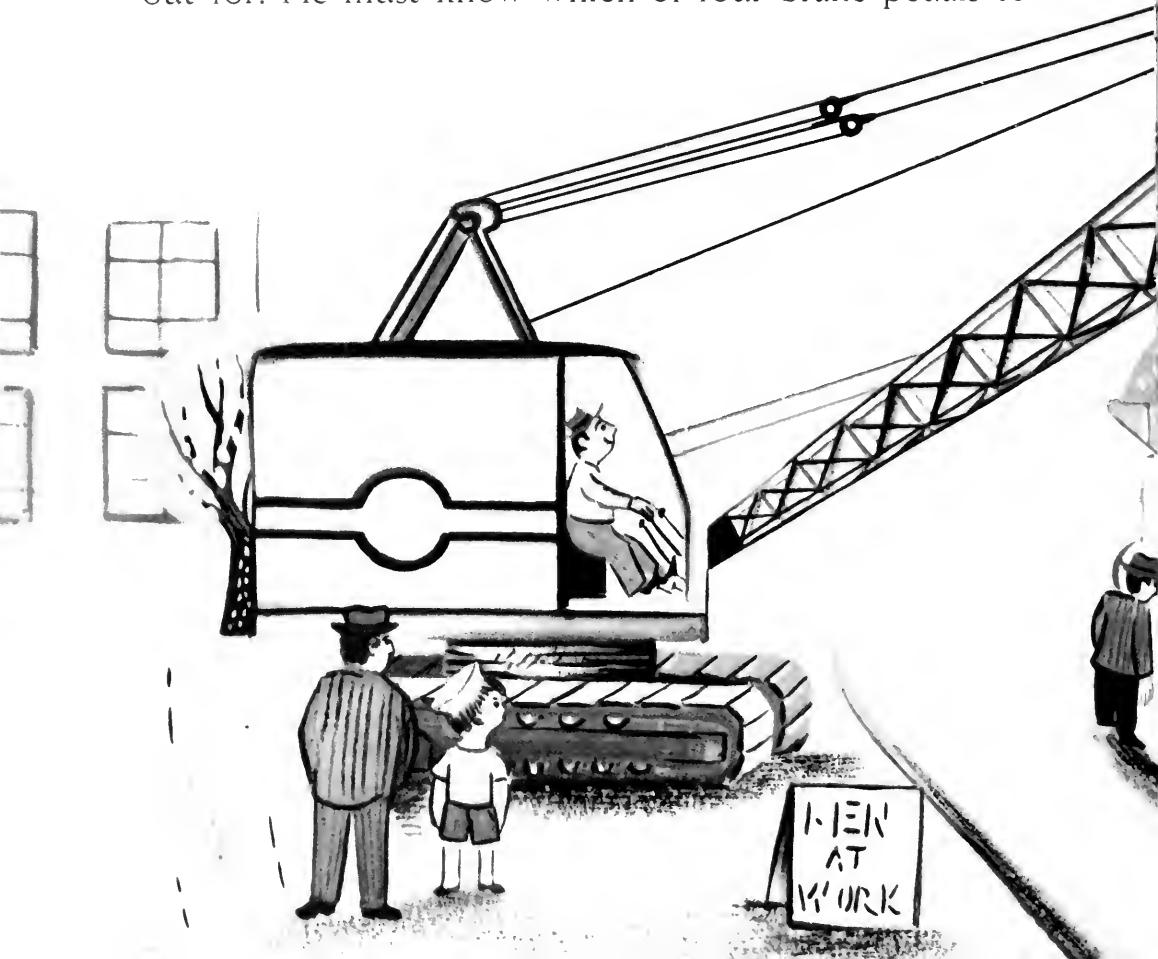
Another shovel digs in the opposite way. It's called a pull shovel. The teeth dig down and toward the driver. It can work from a bank and doesn't have to go down inside the hole at all.

Sometimes Charlie uses a crane to get loose earth out of a hole. The crane has a long boom with wheels at the tip. Cables run over the wheels. Charlie fastens a kind of bucket called a clamshell to the cables. With its mouth open, the clamshell drops down over a heap of rocks and earth. Then Charlie starts machinery that pulls up on the cable. The jaws of the clamshell squeeze together and come up with a load of earth. Now Char-

lie swings the whole crane around till the clamshell is hanging above a truck. He pulls a cable that opens the bucket, and the earth and stone tumble out.

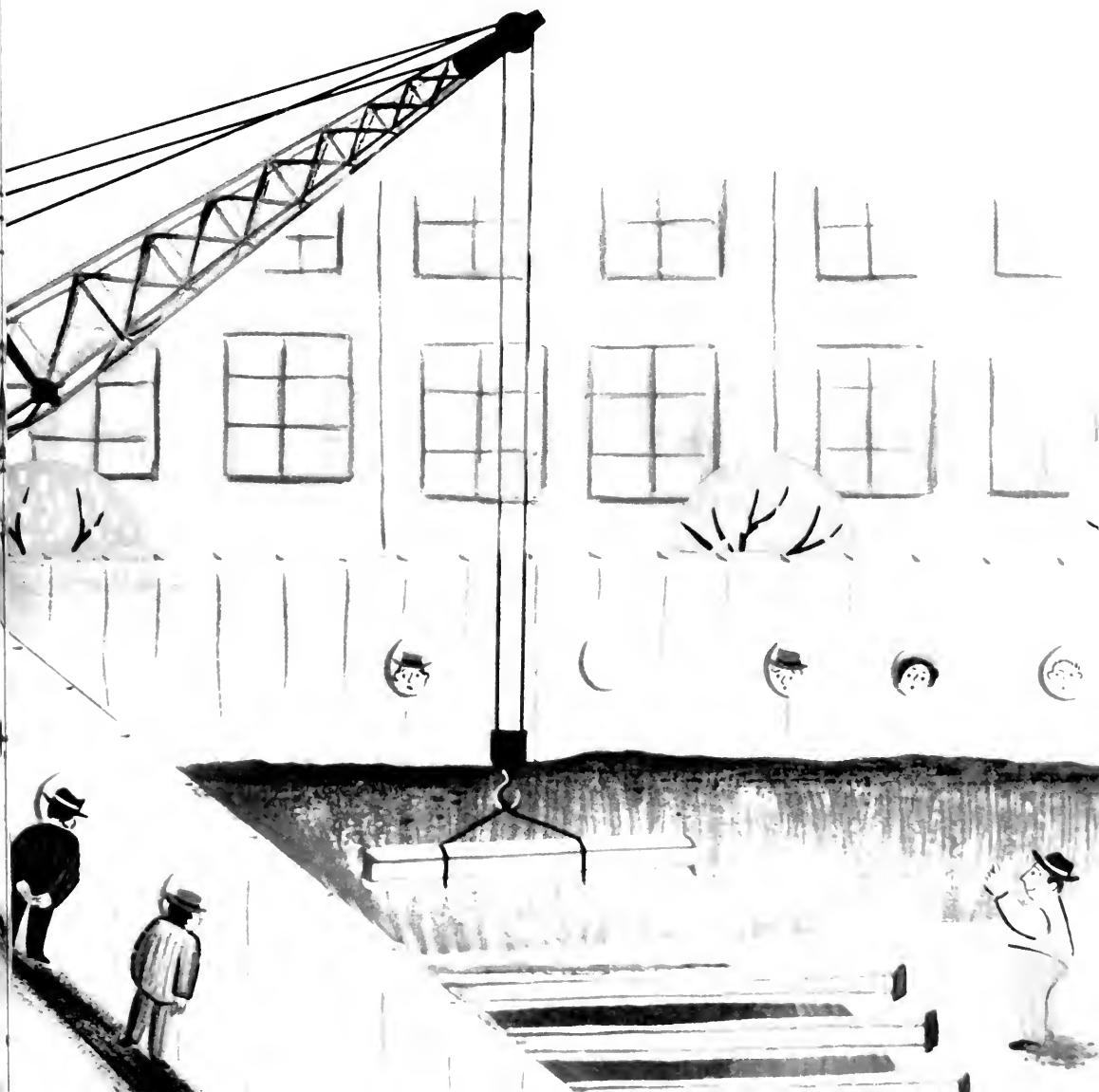
After the basement for a building has been dug, Charlie uses the crane for other jobs. Men hook the cables to heavy steel beams, and Charlie lifts them into position.

No matter what he is doing, he has a lot to watch out for. He must know which of four brake pedals to



use at any moment and which of four hand levers to pull. One lever works the turntable which swings the whole house around. One moves the boom up and down. The other two control the cables.

At the same time, Charlie must watch what's going



on outside. A man stands on the job giving signals. Thumbs up mean "Take the boom up." Thumbs down mean "Lower the boom." When the signal man points up with his first finger, it means "Raise the cable." If he wiggles the finger, it means "faster." When Charlie is lifting a beam and has to hold it for a while in the air, he says he "takes a strain and dogs it off." Dogging is his word for setting the brake on the cable.

Things are always likely to fall around a construction job, so the men who work on the ground have steel caps in their shoes to protect their toes. They wear steel helmets on their heads, too!

As the building goes up, Charlie's crane lifts loads higher and higher. After a while he has to put a jib on the boom. This is an extension that makes it longer. When the building goes too high for his crane to reach, Charlie works another crane. It sits on top of the building's framework and reaches down from there.

After Charlie lifts a big steel girder into position, other men bolt it in place then fasten it tight with

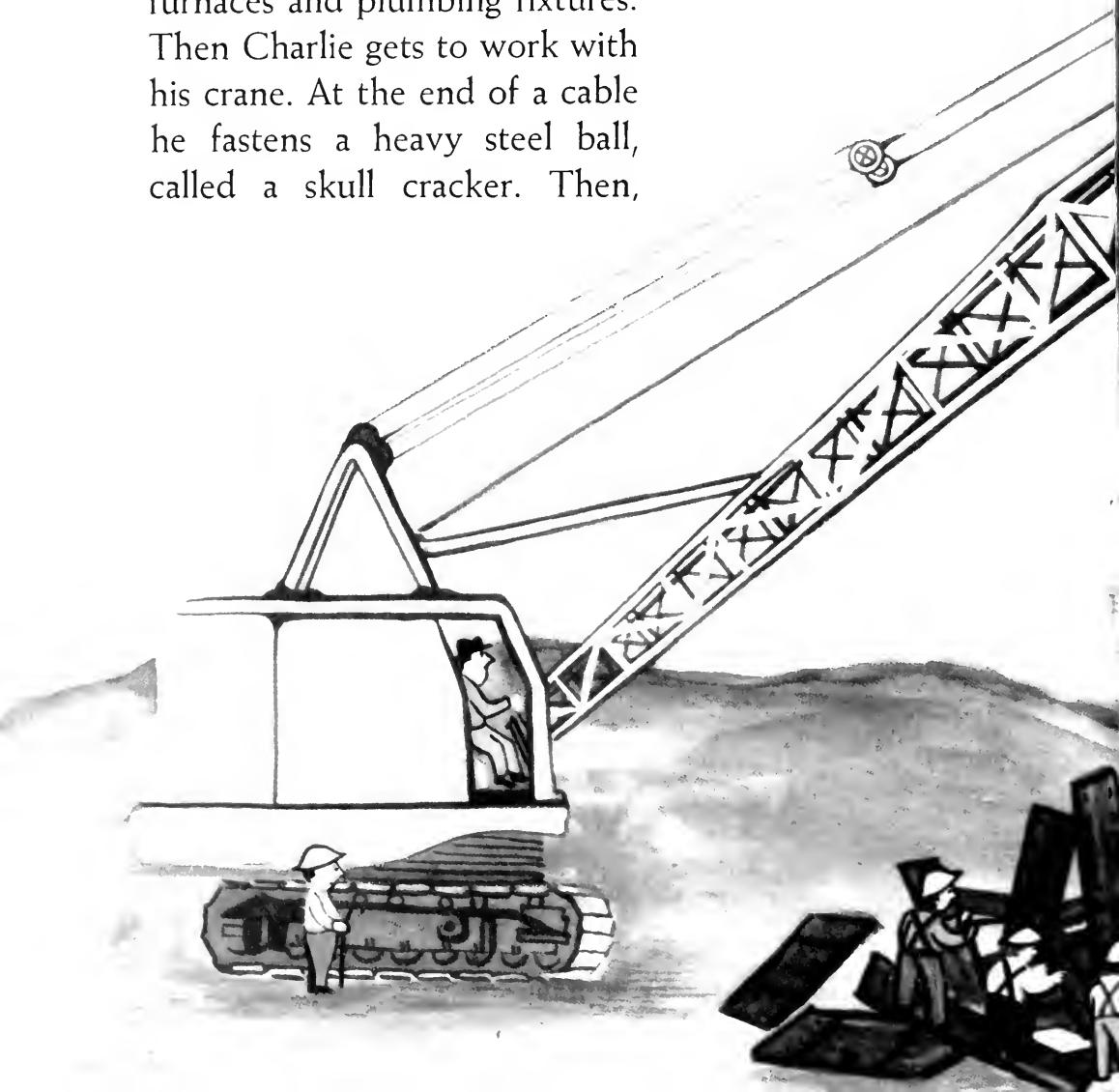


rivets. A man called a heater gets the rivets red-hot in a fire. Using tongs, he tosses them one at a time to the catcher who reaches for them — not with a mitt but with a kind of cup. The catcher pokes a rivet in a hole, and two other men fasten it tight. One of them, the bucker, holds the rivet in position with a bar, and the rivet man pounds the other end flat with a rivet gun. (The gun works like a jack hammer, and it makes an awful racket.)

When you're down in the street, it's hard to realize that there may be a heavy wind blowing across the bare girders of a tall new building. High in the air, men have to keep their balance on narrow places and walk with sure feet. There are families who specialize in work far above the solid ground. Boys learn from their fathers how to walk safely without being afraid — although almost everyone is frightened at first. And, of course, everyone is careful. In New York a group of Mohawk Indians have worked on many high buildings where men like Charlie did the beginning work.



Once in a while Charlie helps to wreck an old building before putting up a new one. First, a crew of men go in and take away everything that can be used again or sold for junk. With specially made crowbars, they pry away floors and door frames. They take out furnaces and plumbing fixtures. Then Charlie gets to work with his crane. At the end of a cable he fastens a heavy steel ball, called a skull cracker. Then,

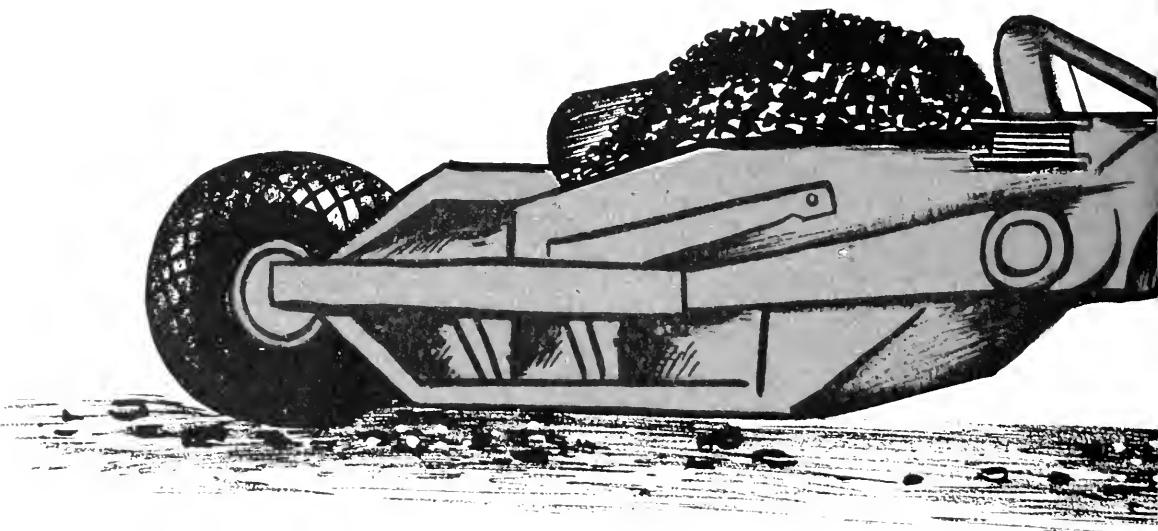




swinging the boom, he bashes the skull cracker into the wall of the old building. Over and over, the ball strikes the mortar and bricks. Cracks spread, and big chunks of the wall start tumbling to the ground. In a little while Charlie and his machine have made a heap of rubble out of a house that it took dozens of men to put up.

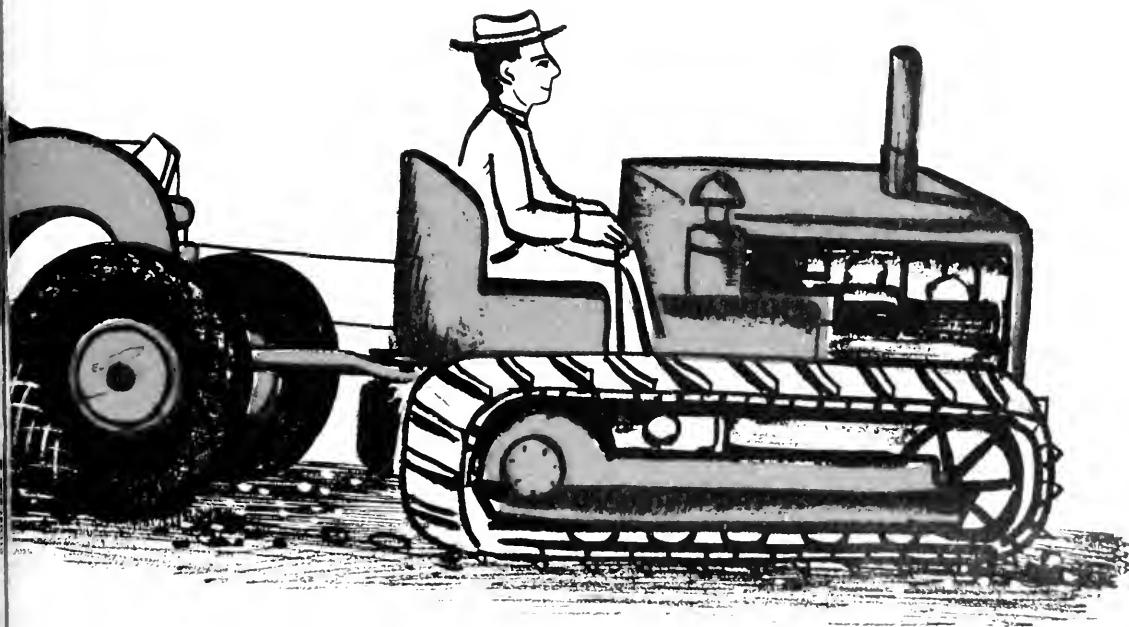
BUILDING A ROAD

Once Charlie worked on a road-building job. There he used a crane and a shovel and many other machines besides. This particular road had to cross a big swamp near the ocean. So the first problem was to fill up the swamp with something solid. In order to get enough earth and rock for the fill, men would have had to tear



down a whole mountain. Instead they called in suction dredge machinery for the job. The huge pumps sucked sand from the bottom of the sea and poured it through pipes onto the swampy ground. When the water drained away, millions of tons of fine white sand were left.

Charlie helped level the sand off with a bulldozer. Then he moved on to a place where a hilly spot had to be leveled. There he drove a carrying scraper, a machine with a scoop between its front wheels and its rear wheels. The sharp scoop scraped up a load of earth, and Charlie drove off to dump it in a low spot. When he got there, a pusher blade at the back of



the scoop pushed the earth out. Round and round he went, without having to stop for loading or unloading.

Other men used a different machine like the one in the picture. This earth mover carried more in one load than the motor scraper, and it was better for hauling earth longer distances. For very short hauls, Charlie drove a fast little tractor. At least it looked small compared to the giant machines. It pushed a scoop in front of it like a shovel, then lifted a load, turned swiftly and dumped the earth where it was needed a few yards away.

Charlie's road was going to be a special highway for speedy traffic. In order to make it as safe as possible, the crossroads had to be lifted up over the new highway. Crews of men built these overpasses. First they used the huge earth-moving machines to make little hills on each side of the highway. Then they built bridges of concrete and steel between the hills.

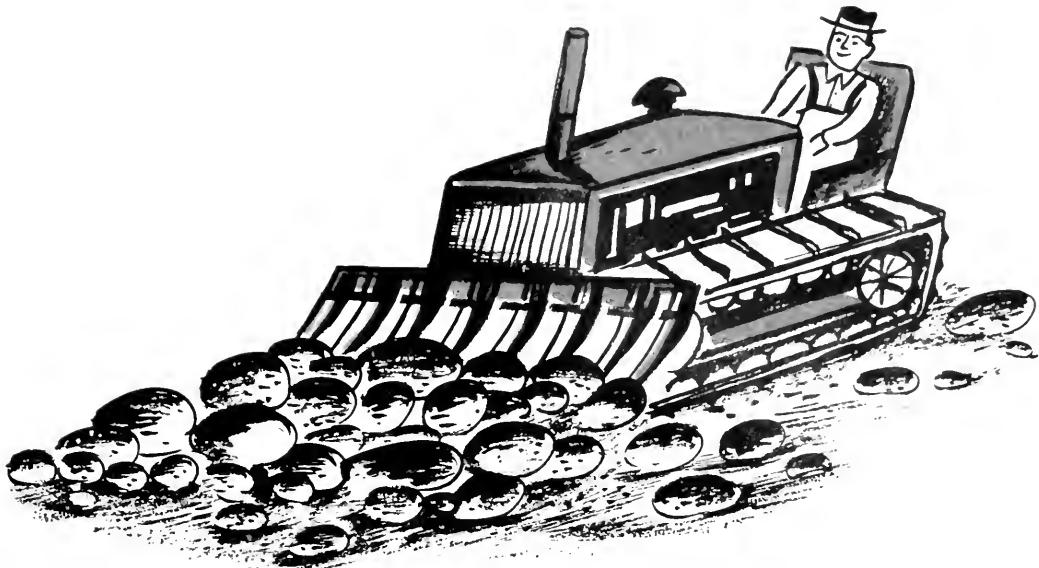
At one place, there were two houses on the exact spot where the hill for an overpass had to be made. Instead of tearing the houses down, moving men just carried them away with the furniture still inside. First they raised the houses off the ground with jacks. Next a tractor backed a wide, low trailer up close to each house. Using special machinery and rollers, the men



eased the whole building onto the trailers. That same night, the houses were set down on new foundations, and the people went right on living in them.

At one place, a big ledge of rock was in the way of the new road. Men called powder monkeys blasted the ledge to smithereens with explosive. Then Charlie came in with his caterpillar tractor and a rock rake. Unlike a garden rake, which you pull, Charlie's rock rake scratched up rocks and pushed them ahead of it. He shoved all the loose chunks of stone away, but several big ones were too far underground for the rake to pry them loose. So Charlie put a ripper on behind his tractor.





The ripper had strong prongs that could dig down deep and get a good hold on a boulder. The frame that held the prongs was hollow. For very heavy work, Charlie filled the hollow frame with sand to give it a lot of weight so the prongs wouldn't slip. To pry out the very largest boulders, Charlie sometimes got another driver to hitch his caterpillar onto the ripper. Then the two tractors, chugging together, did the job.

After the bulldozers and scrapers and rakes had built a rough bed for the highway, Charlie helped to smooth it down and get it all ready for finishing. He used a long six-wheel motor grader for the job.

The motor grader had its Diesel engine in the rear,

above the four wheels that did the pushing. The guiding wheels were way off at the front, and in between was the scraping blade, placed where Charlie could watch it.

Charlie could set the blade at almost any angle, just as a barber can tilt a long-bladed razor. And Charlie was proud of the way he had left the road almost as smooth as a barber leaves a man's face.

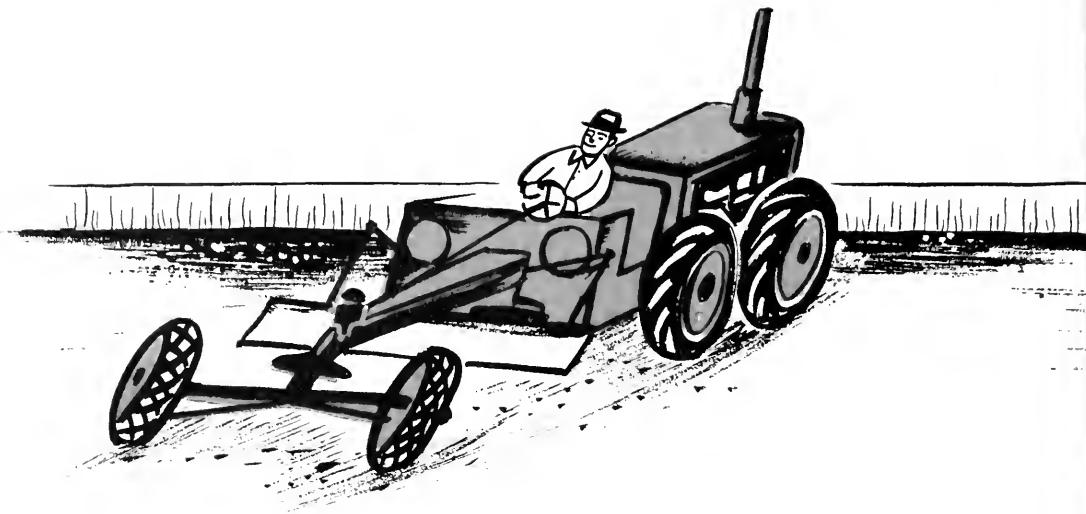
Charlie could play tricks with the motor grader's front wheels, too. Besides steering them in the ordinary way, he often made them lean over toward the right or the left. To look at them, you'd think they were broken, but they were only tilting to do a special job. They were actually in a tug-of-war with the blade and



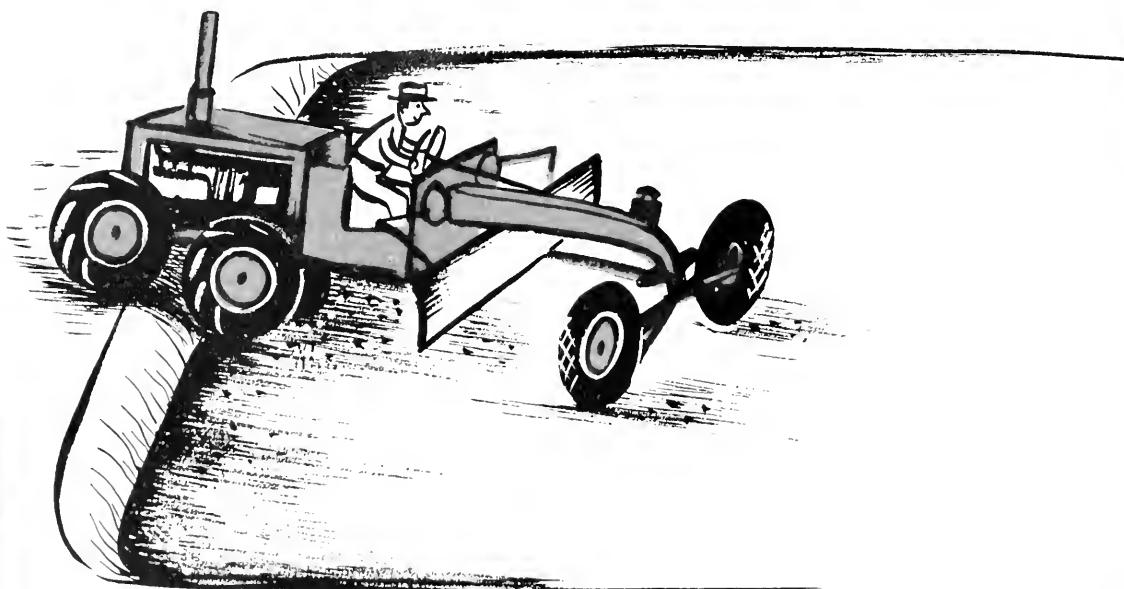
the earth it was pushing. The weight of the earth against the blade pulled the grader toward one side. But the leaning of the wheels pulled in the opposite direction. So the two pulls balanced each other. Charlie could guide the grader in a straight line without having a wrestling match with his steering wheel.

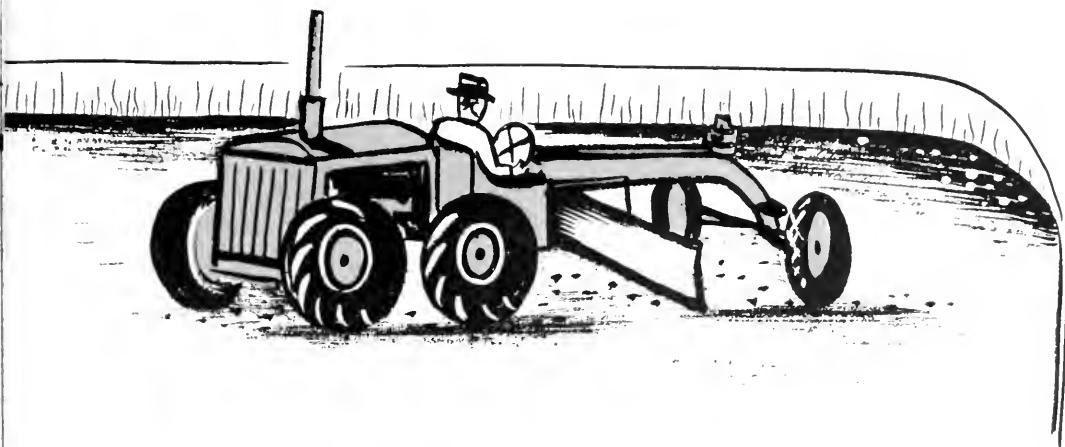
Charlie leaned his wheels when the grader went around a bend in the road, too. They helped the long machine to turn easily. If he had to back into a ditch,





he didn't worry. The great wheels adjusted themselves to the sloping earth. All six wheels stayed on the



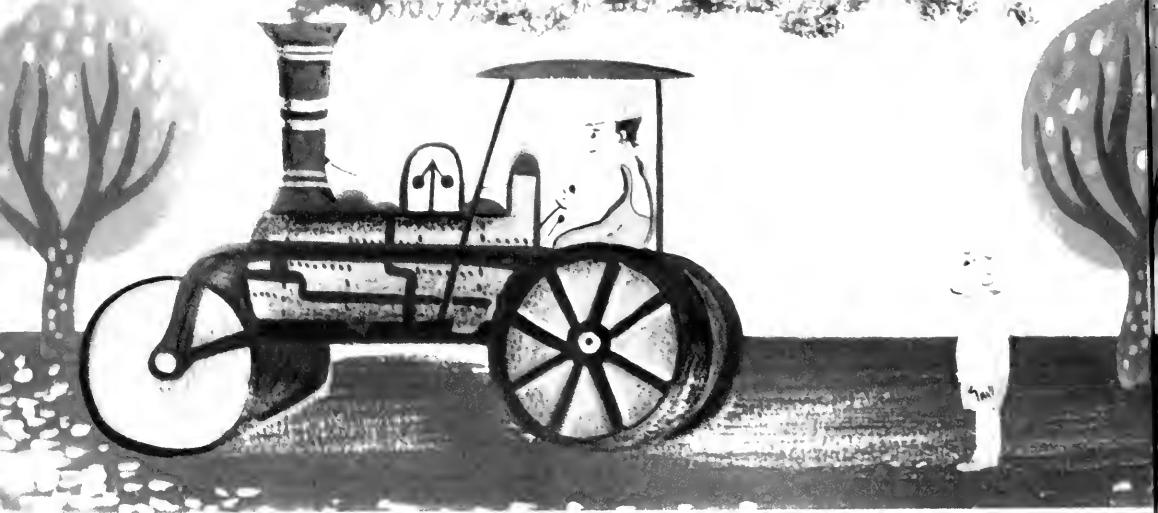


ground, and the machine never got hung up the way a four-wheeled automobile would.

When the earth had been smoothed down, it was time to put the hard surface on. Trucks brought in crushed rock to make a solid bed. Concrete mixers covered the rock with concrete. And asphalt spreaders put a coat of asphalt on top.

Wherever the asphalt wasn't spread evenly, men with rakes finished the job by hand. Then came the tandem roller to pack it down and make the surface smooth.

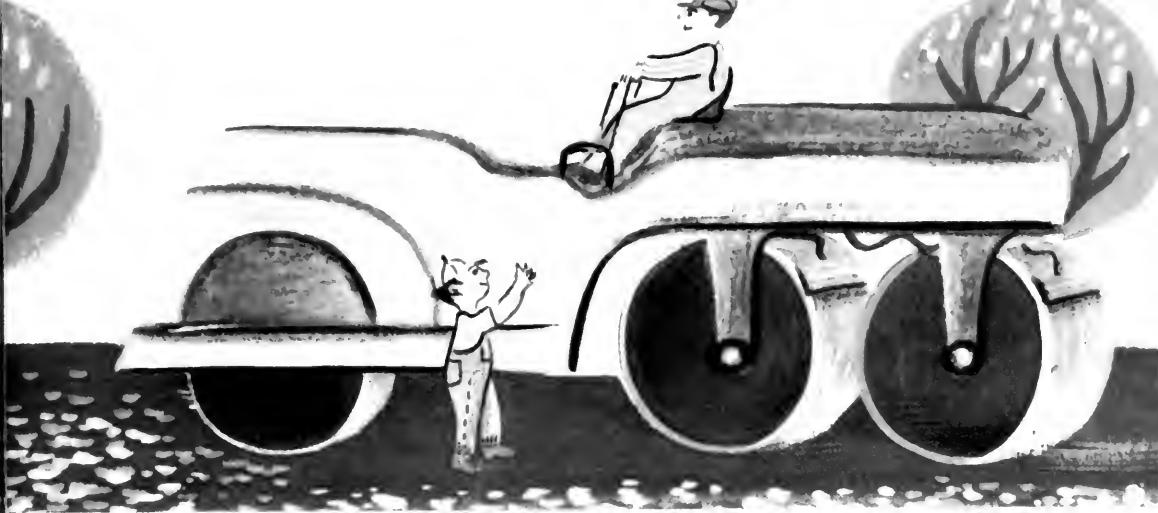
A Diesel engine moved the roller's great weight quickly back and forth over the asphalt. In no time the road was as smooth as a table top. If the driver wanted



to, he could turn his seat sideways. Then he could easily see whether he was guiding the roller straight forward and straight back.

Many people call road rollers "steam rollers." That's because the first ones really were driven by steam engines. Men have a lot less fuss and bother with a modern Diesel-engined tandem. There's no need to start the fire or shovel coal to keep steam up. You can still see some steam rollers at work, though, because they are strong machines that last a long time. But when one wears out, it is replaced with a modern roller.

After the roller finished smoothing all the asphalt down, Charlie's road was ready for traffic, but the job still wasn't quite done. All along the highway the machines had left bare banks of earth. These had to be protected from the weather — just the way a house is protected with a coat of paint. The best coat for the



earth is grass of one kind or another. So Charlie turned gardener. In some places he used the motor grader again to prepare the soil so that seed could be planted. With the blade of his grader hung away out at the side and pointed up in the air, he smoothed off the steep banks. Running along the edge of the road, he filled in the soft shoulders.

Then a seed-planter sowed the grass. And finally Charlie used the strangest machine of all. It chugged and puffed and spit out great mouthfuls of hay, which fell over the newly-planted grass! The hay protected the grass seed and kept it moist until its roots were growing strongly in the soil.

MORE ROAD WORK

The road was finished now, but some of the machines still had work ahead of them. In fact, road work is never ended.

All summer long, tractors pull mowing machines beside the highways, cutting the grass. Brush and small trees must be kept cleared away so that drivers can see ahead. In winter, the motor graders and the snow plows can keep the road clear. But in places where heavy snow piles up into drifts, caterpillar tractors often push special snow plows that eat through the drifts with powerful whirling blades. With one motion these plows dig out the snow and throw it off to one side of the road.

The caterpillar treads work better in snow than wheels with tires. So the "cats" are used all winter long in the Far North. There they even pull whole trailer trains on runners. The one in the picture is hauling



Muskeg schooners, which are really trailer houses on sleds. Muskeg is an Indian word for swamp. The dogs pull the schooners over frozen, snow-covered swamps.

You may wonder why anyone wants to use a trailer home in the roadless wastes of the Far North. The fact is that men work there the year round, prospecting for oil. When they think they have located oil there or anywhere else, well-drilling machinery goes to work.

DRILLING MACHINES

Everybody knows that oil wells and derricks go together. The tall derrick towers are needed to hoist drilling equipment in and out of the hole.

When men start to drill a well, they fasten a cutting tool, called a bit, to a piece of pipe which hangs upright

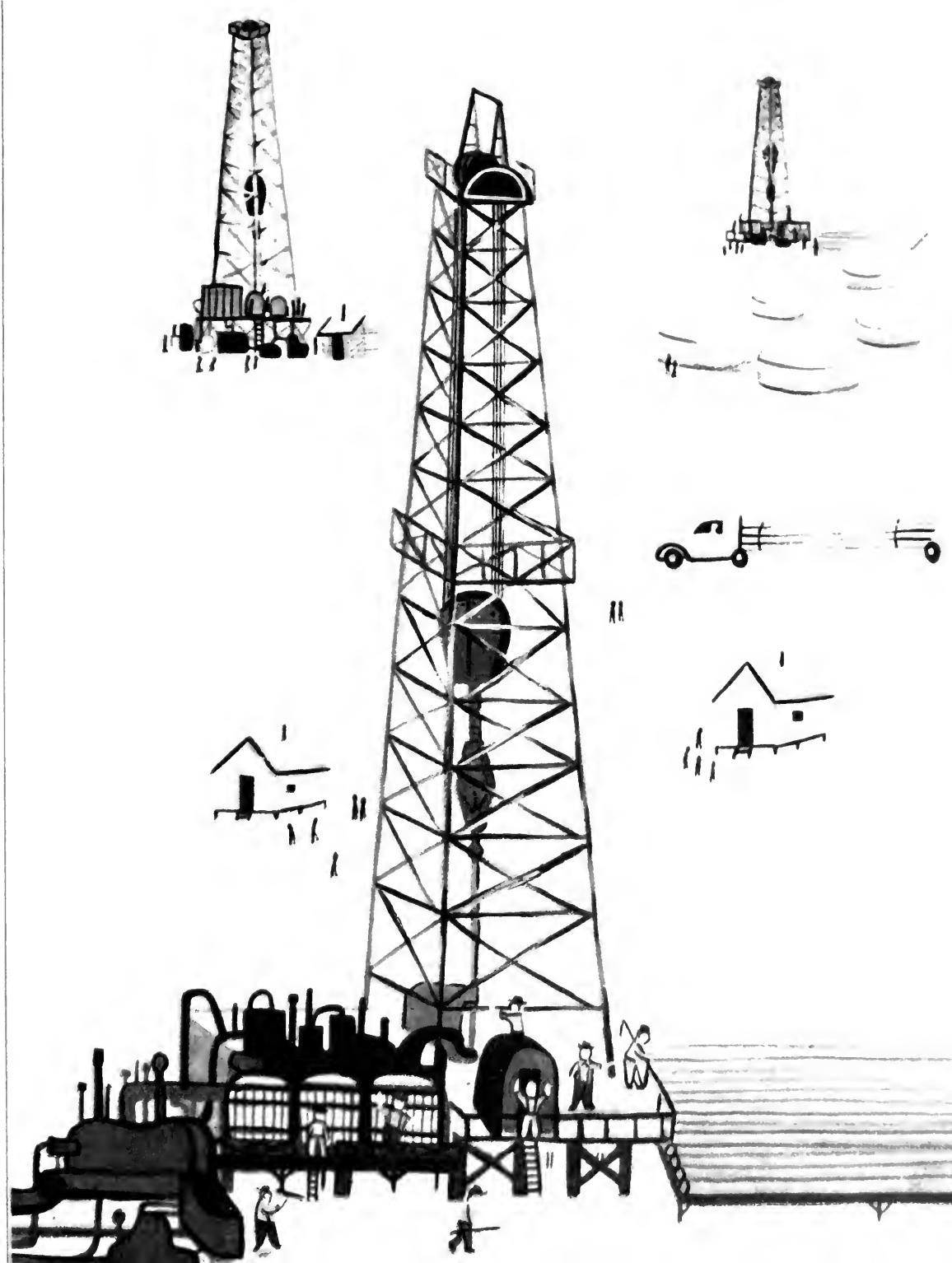


in the derrick. Machinery turns the whole thing round and round, so that the bit grinds down into the earth. When one length of pipe, called a joint, has almost disappeared into the hole, men screw another joint onto the top of it. Now the engine turns the double-length pipe, and the bit digs down deeper.

Men, working on the floor and high up in the derrick, hoist more and more joints into position and screw them together as the bit goes on down. After a while, the bit gets dull. A new one must be put on. So, strong cables that run over wheels at the top of the derrick begin lifting the whole string of pipe out. Joint by joint, they unscrew the pipe and stack it out of the way. When the last joint comes up, men change the bit. Then back the pipe goes, joint after joint, into the hole.

Wells must often be drilled more than two miles deep before the bit breaks through into an underground reservoir of oil. That means that the string of drilling pipe must be two miles long. The machines that help to handle it are very strong, but on many rigs, men have to use their own muscles a great deal, too.

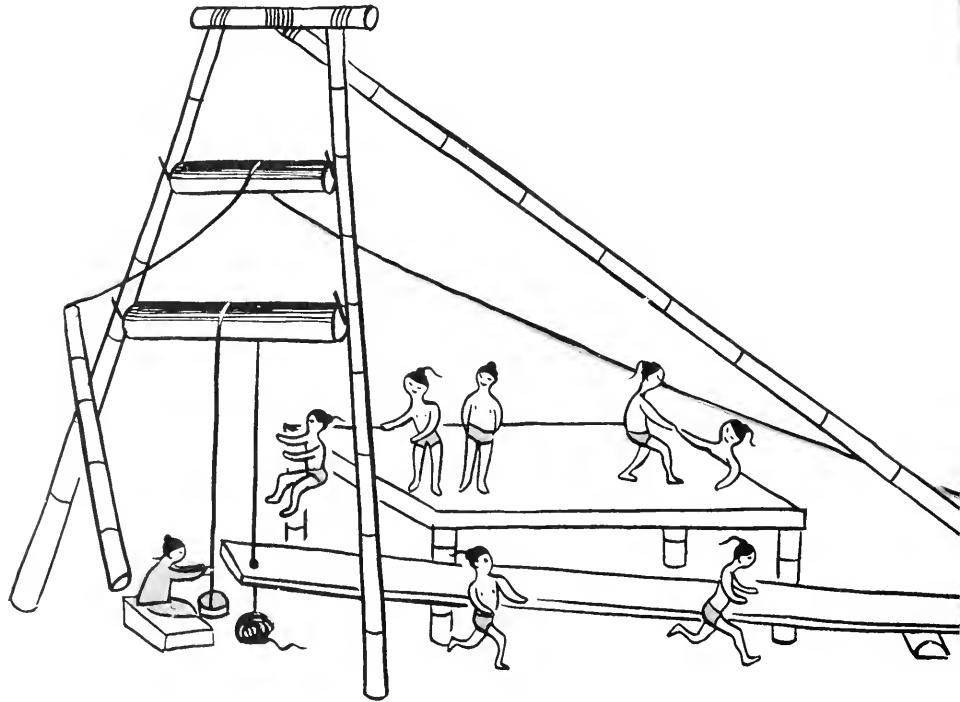
For deep drilling, the most modern rigs have a lot of fine new machinery. Automatic tongs take a tight grip on the drilling pipe when it is being unscrewed. Men used to work the tongs by hand. Mechanical hands



now keep the bottom joints from dropping back into the hole, and arms high up in the derrick do the job of stacking the pipe.

The skillful men who work with the pipes and the machinery call themselves roughnecks. The driller is the one who actually controls the drilling pipe. He never says he is digging a well. He says he is "making hole."

Almost all deep wells are now drilled by the turning pipe and bit, which are called a rotary rig. But sometimes you can see an old-fashioned cable rig at work. It makes hole with a bit that pounds its way down into earth and rock. A cable raises the bit, and then lets it fall down with a bang that chips away a hole. On both

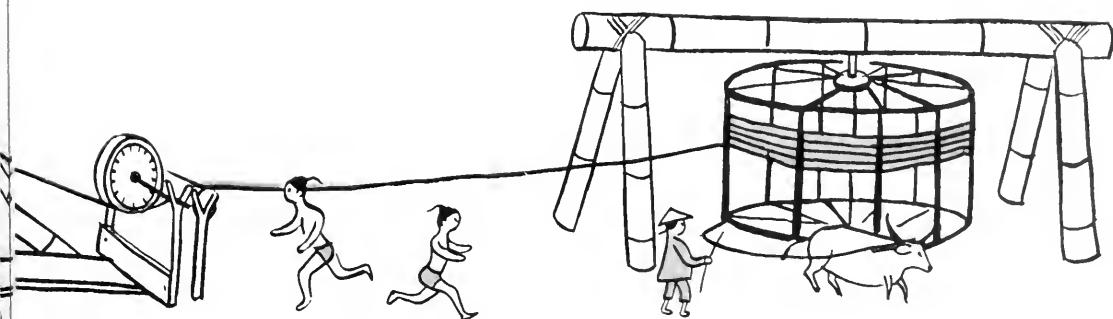


kinds of rig, the hole is cleaned out with water. The water turns the rock dust into mud, which is then pumped out.

The cable rig idea is about two thousand years old! That long ago Chinese drillers made water wells, salt wells and even oil wells. The picture shows what one of these ancient rigs was like.

Look first of all at the long board attached to the rope that goes up over a roller and down into the well. Then look at the platform behind the board. Men jumped from this platform down onto the board. That jerked on the rope and pulled the drilling bit up in the well hole. When a man jumped off the board, the bit fell down and chipped away some rock. Round and round a whole crew of men raced, jumping onto the board and climbing back onto the platform as fast as they could. Still it took a long time to drill a well — sometimes as long as ten years.

Now look at the big wheel turned by a bull at the right. This wheel lifted the pipe made of hollow bam-



boo that you see at the left. The pipe was actually a bailer. Every once in a while the men poured water into the hole, let the bailer down and hauled up mud. Then the bit could go on drilling. Oil workers today still call the wheel which winds up cable "the bull wheel."

PIPELINE MACHINES

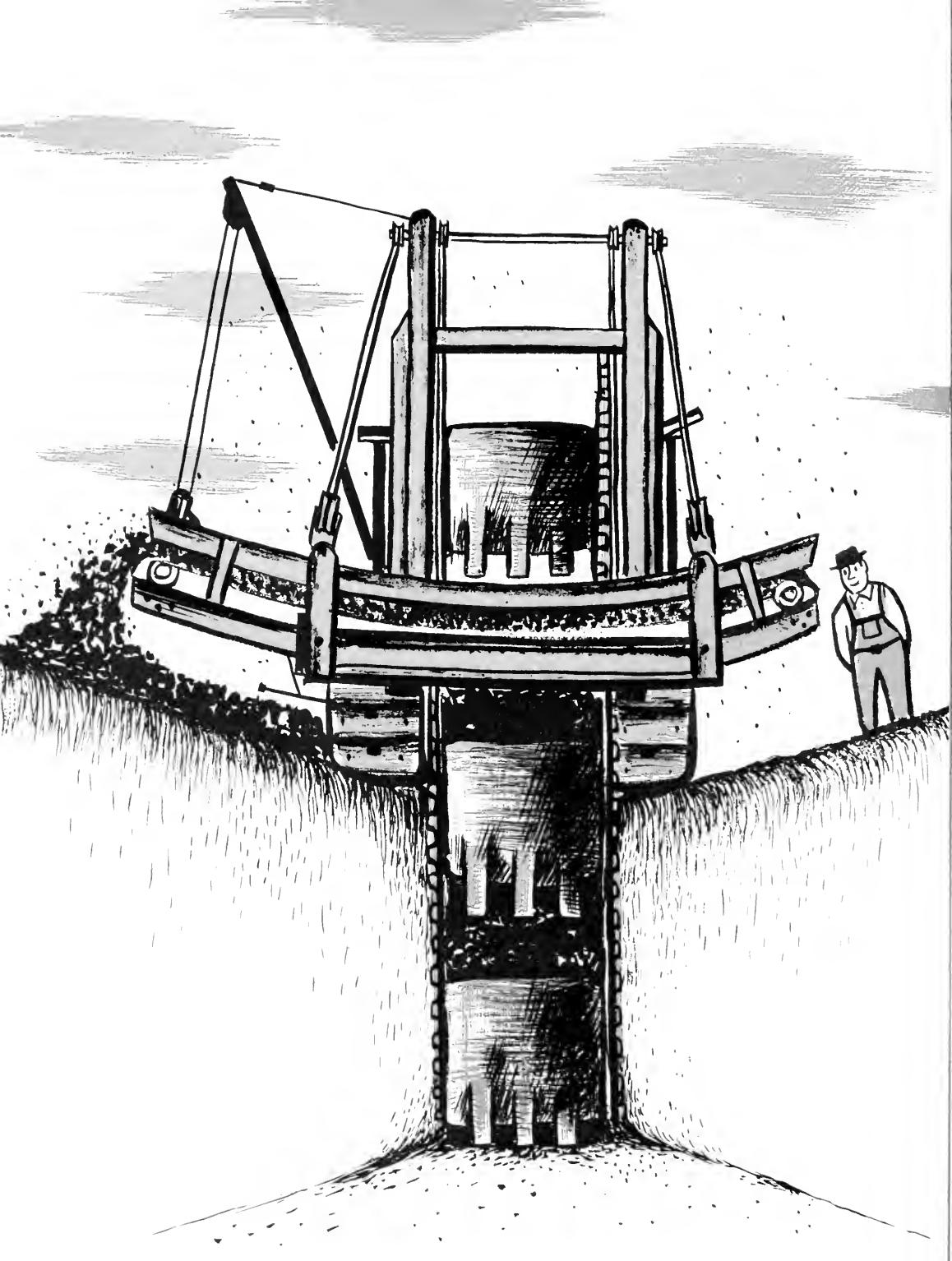
When a well brings in oil, a new group of men and machines go to work. They lay a pipeline, through which the oil can be pumped to factories called refineries. Some pipelines are hundreds of miles long.

After surveyors have decided just where the line should go, bulldozers clear away brush, push over trees, heave big boulders to one side, making a wide pathway across country. In many places, the pathway is good enough for trucks to follow. They bring in lengths of pipe and lay them down end to end. Where the going is rough, a caterpillar tractor carries the pipe, one length at a time, hanging from a side-boom.

Now welding crews go to work fastening the ends of the pipe-lengths together. When they have finished, the "hot-dope gang" comes along. They are men who cover the pipe with a wrapping and then with a hot asphalt mixture to protect the metal.

Meantime, a wonderful machine called a trencher has been at work. This is a cat attached to a rig which

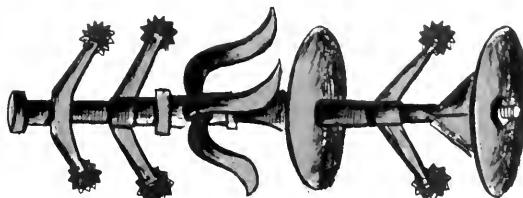




looks very much like an old-fashioned water wheel. Each bucket on the wheel has steel teeth. The cat turns the wheel and pulls it forward. The buckets scoop up earth, and spill it out onto a belt that dumps it in a heap at one side. The trencher plugs ahead, uphill and down, digging a ditch just the right width and depth.

Following behind the trencher, cats with booms hoist up the snaky pipeline and ease it over into the trench. Finally, bulldozers backfill the trench. That is, they cover the pipe with the dirt that the trencher left alongside. On one job, the men had to work at top speed in the desert and in rocky, mountainous country. They were all so glad they'd finally succeeded in getting the pipeline built that they put on a celebration. Whooping and hollering, they tossed their sweat-stained hats into the trench in front of the bulldozer as it backfilled the last few feet of earth.

Even after that there was one more tool that had work to do before oil could be pumped through their pipeline. It is a peculiar gadget that looks like a bunch of cowboy spurs hooked up with pieces of tin can and some old plates. The weird contraption is called the go-devil, and it has the job of traveling, perhaps hundreds of miles, inside the pipe, pushing out anything

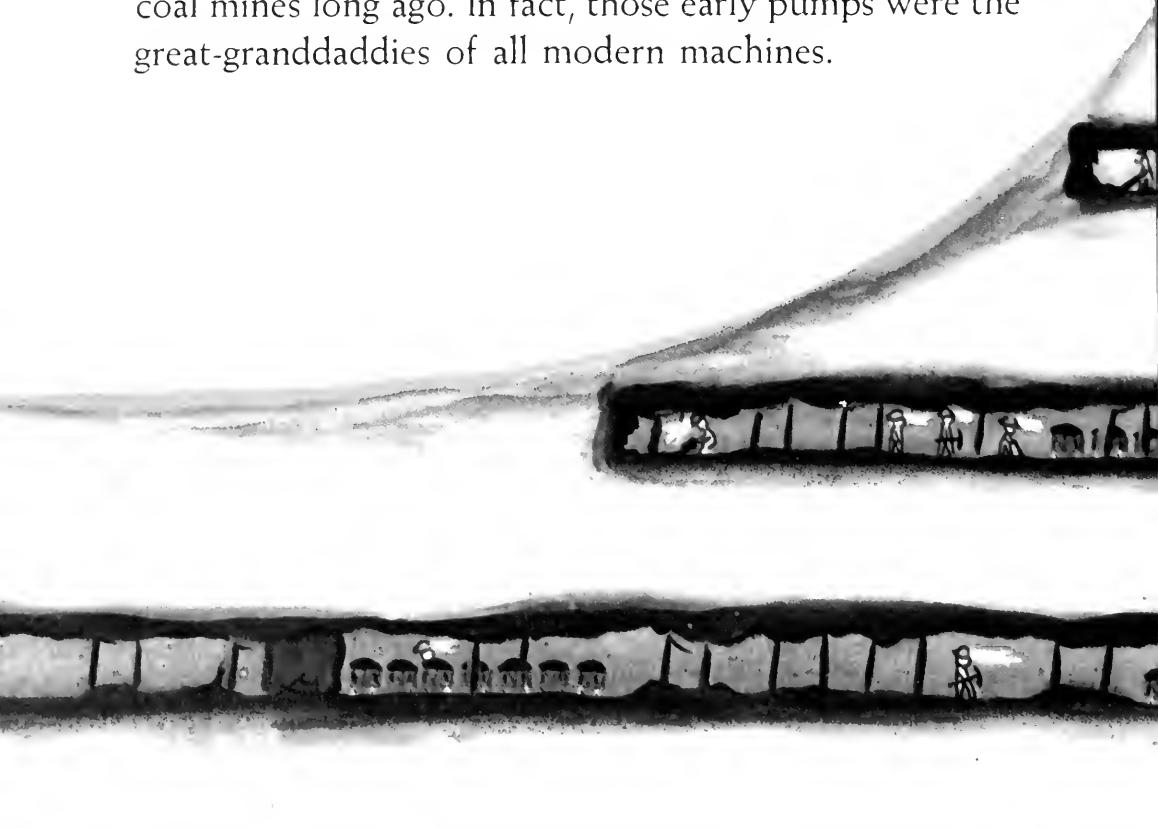


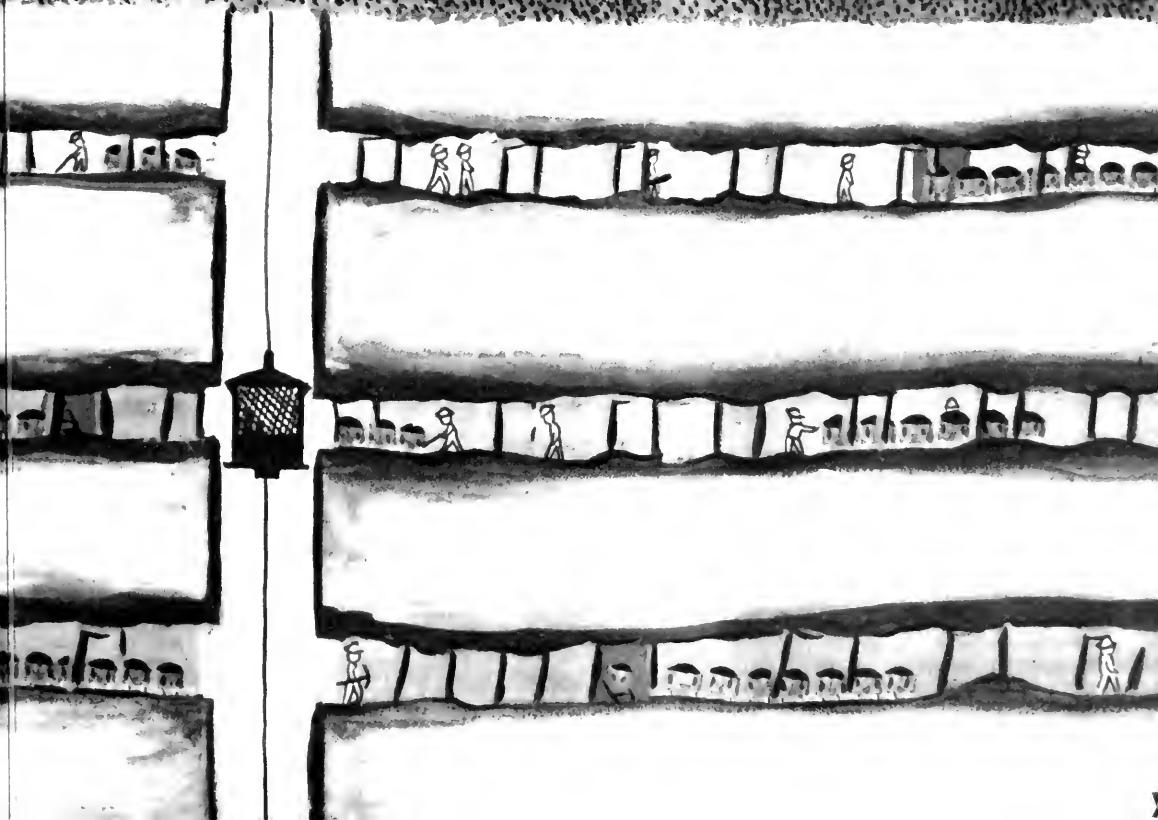
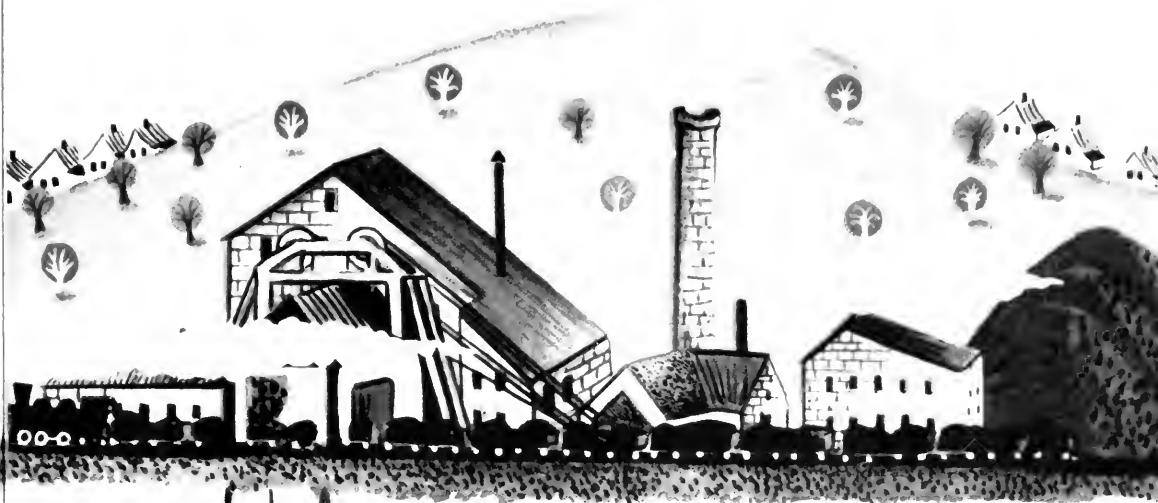
that could clog the line. Water pumped into the line behind the go-devil forces it through the pipe.

In one line, the go-devil brought out chunks of wood, pieces of rock — and several rabbits, skunks and rattlesnakes that had decided the pipe would make good headquarters! Now the powerful pumps could go to work shoving oil through the line.

MINING MACHINERY

Oil pumps today are much better and stronger than the first pumps ever built, but they are direct descendants of the ones that were invented for use in English coal mines long ago. In fact, those early pumps were the great-granddaddies of all modern machines.





Coal miners in England had dug so far beneath the surface of the earth that the shafts and tunnels were in danger of filling up with water. Neither manpower nor the power of horses hitched to pumps could do the tremendous job of keeping the mines dry. Something much stronger was needed. In order to find a new kind of power, inventors began experimenting with steam. The first workable steam engines were made to pump out coal mines more than two hundred years ago.

After a while steam engines began to pull trains over rails and drive ships through the water. They ran threshing machines on farms. Then inventors used their new knowledge about power to make other kinds of engines driven by gasoline or electricity or oil.

At last some of this new machinery began to work its way back into the mines. Power driven elevators carried the men up and down shafts to their work. But

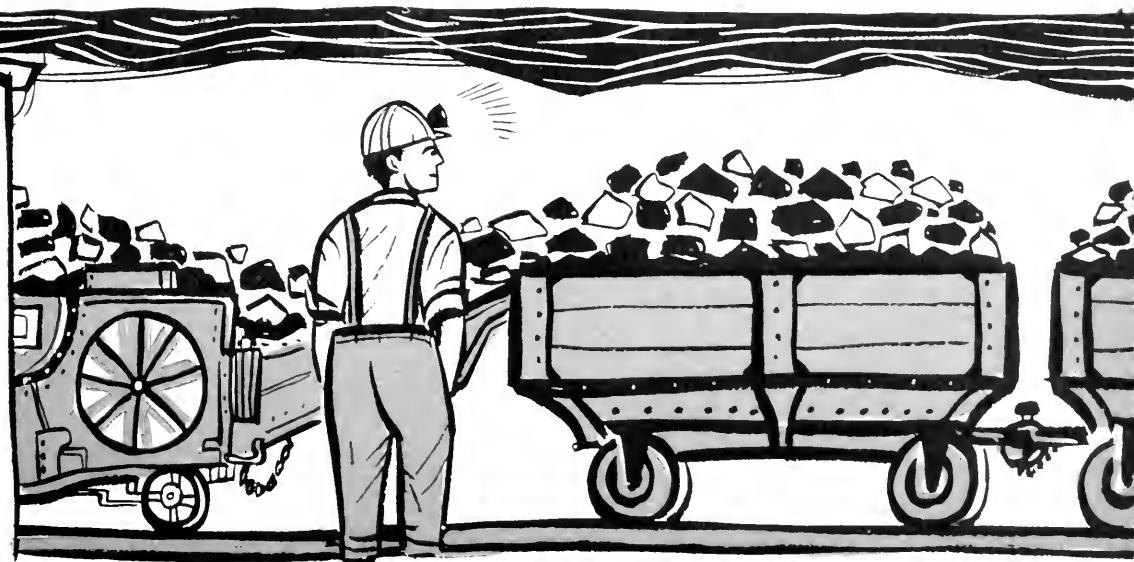


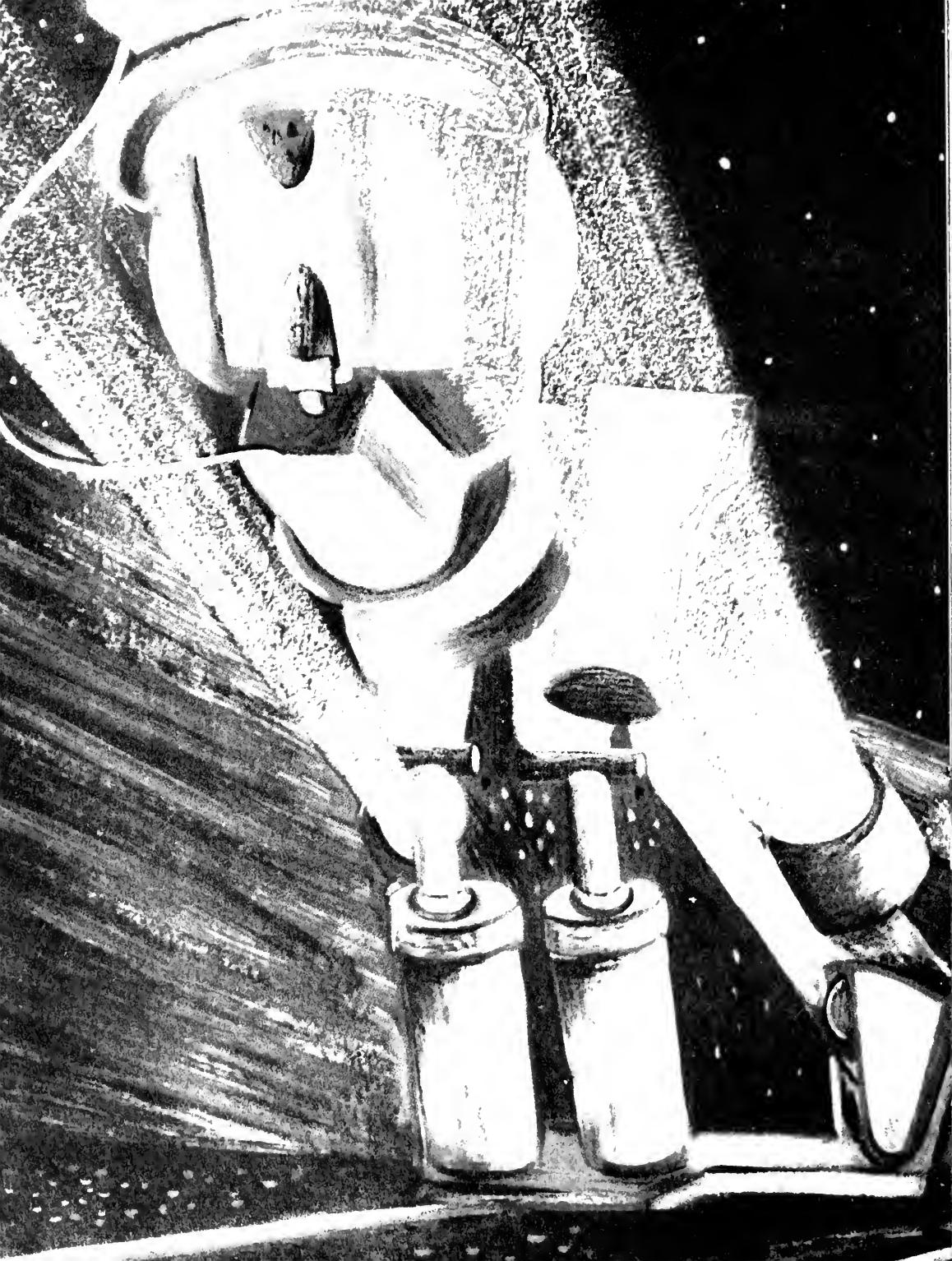
the miners still did all the coal digging and loading by hand.

Today many miners use power-driven drills for digging. Mechanical loaders pick up the loose coal and put it into small cars on the tracks in the tunnel. A little electric locomotive pulls the cars away to the elevator which hoists them up above ground.

The most remarkable digger of all is the one you'll see on the next page. It rolls along a track deep underground until it comes to the place where its operator wants to cut coal. He pushes a control, and the machine's long neck reaches up. The cutting head, at the end of the neck, starts biting into the coal. The head does its work much faster and easier than men with hand tools ever could.

Outside the mine, machines sort the coal according to size and load it into railroad cars.





Unloading machinery empties the cars in many places, too. There's one coal yard where a woman, pushing buttons, controls machines that do everything — unload cars, store the coal according to its size in tall bins, and load the trucks that will deliver it to customers. This is how the yard works:

Each railroad car empties its coal in a stream onto a moving belt. The belt carries the coal to a machine called a giraffe, which works like an escalator. The giraffe lifts the coal into a tall hopper.

The woman who runs the coal yard sits in an office with a big window, where she can look out and see everything that's going on. When a truck has backed up to a hopper, ready to load, she pushes a button. Coal drops down out of the hopper onto another giraffe which lifts it into the body of the truck. As soon as the truck is filled, push goes a button and the loading stops.



LOADERS, LIFTERS AND SUCH

Moving belt machines work at other jobs, too. They load sand into trucks and cargo into ships.

On some piers, huge vacuum cleaners empty ships full of sugar or wheat. At ports on the Great Lakes, machines reach down into ore-carrying ships and unload them with great speed. At the end of each of these unloaders hangs a clamshell bucket. Just above the bucket is a little room where a man sits and watches what goes on. He signals to the operator, telling him just where to drop the bucket so it can pick up a mouthful of ore. The ship can be unloaded by two men who do nothing but signal to each other and push levers. But usually there are several machines working at the same time so that the job goes as quickly as possible.

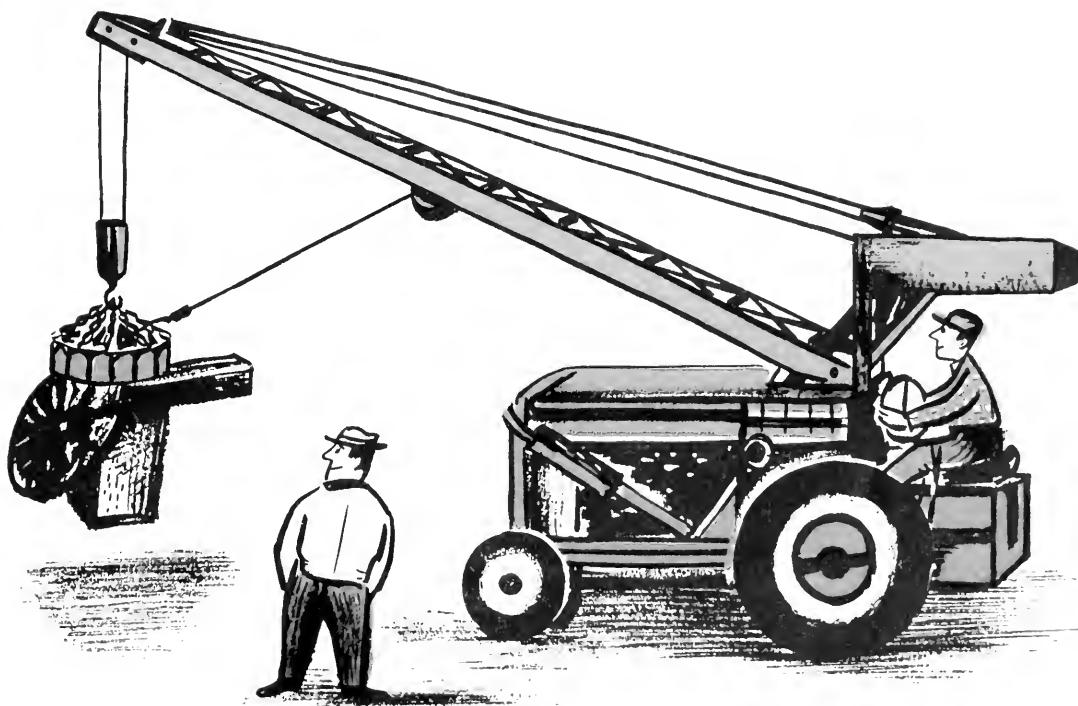
When iron ore has been turned into steel bars or wheels or gears, another kind of lifter can handle them. This one does its work with a huge electro-magnet that holds heavy weights when electricity is running through it. The operator drops the magnet onto the load of iron or steel that he wants to lift. Then he turns on the electricity which makes the magnet and the piece of metal stick together. The operator moves the load wherever it is supposed to go. Then he turns off the electricity. The magnet lets loose and is ready for another job.

MACHINES FOR LUMBER, TOO

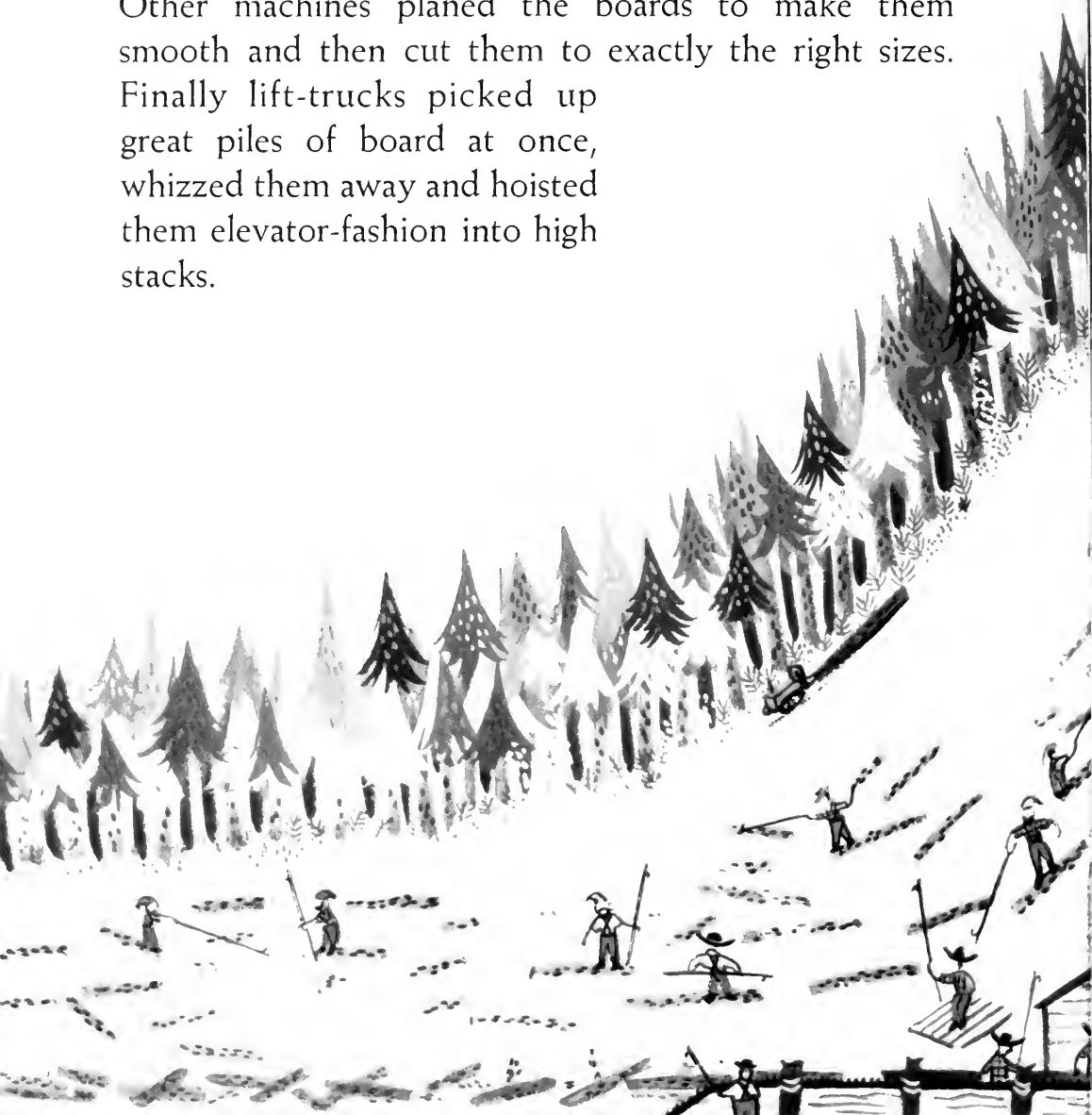
Machines dug and loaded and delivered the coal that keeps your house warm. Machines helped cut the lumber that went into building your house, too.

Far out in the woods, power-driven saws sliced quickly through the trunks of great trees. Caterpillar tractors hauled the logs out along rough forest trails.

Perhaps the cats, using booms, lifted the logs onto extra-long trailers behind trucks and started them on the way to the sawmill. Or the cats may have snaked the logs to a river so they could float downstream to a sawmill.



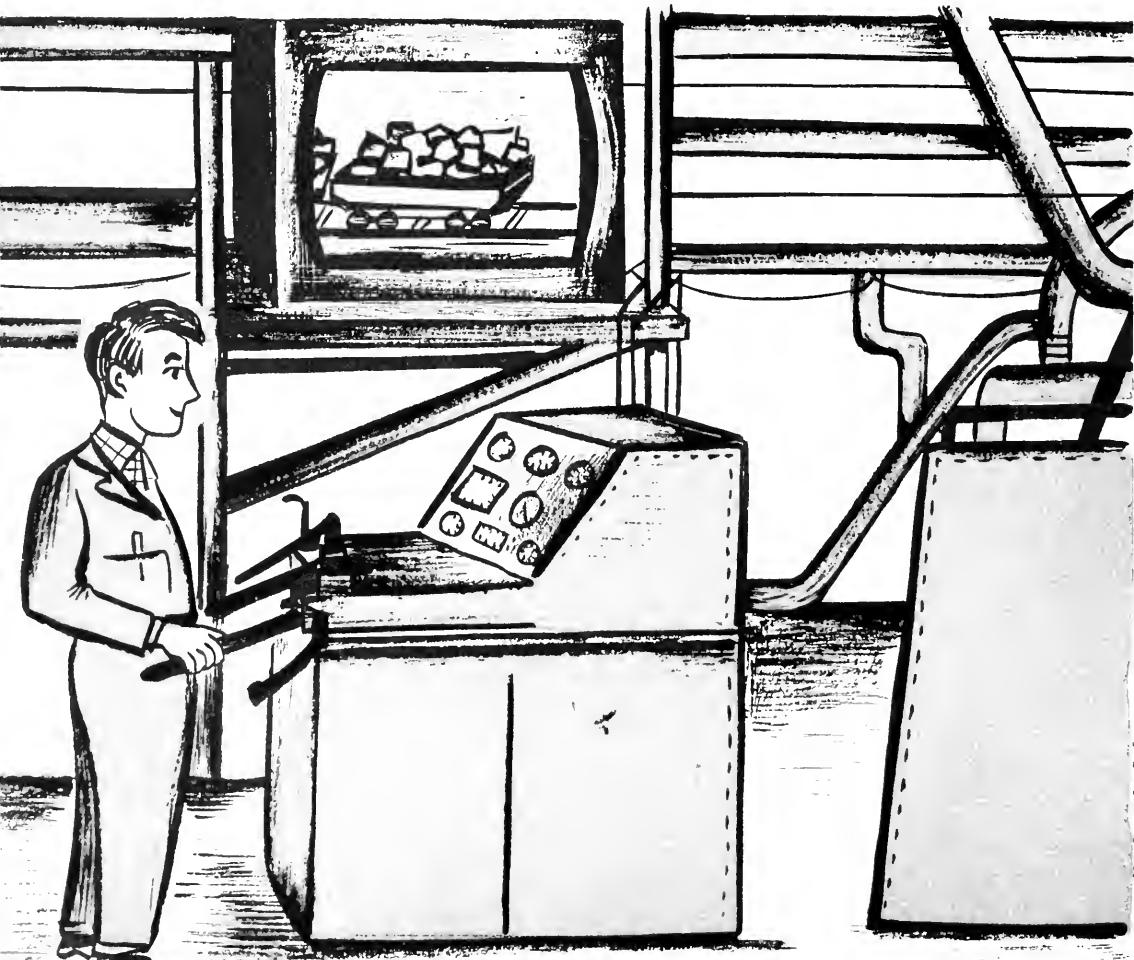
No matter how the logs reached the sawmill, they were put at last onto belts which pushed them against huge whirling saws. A whole set of saws, all whining and screaming at once, turned the thick log into boards. Other machines planed the boards to make them smooth and then cut them to exactly the right sizes. Finally lift-trucks picked up great piles of board at once, whizzed them away and hoisted them elevator-fashion into high stacks.





BRAIN POWER

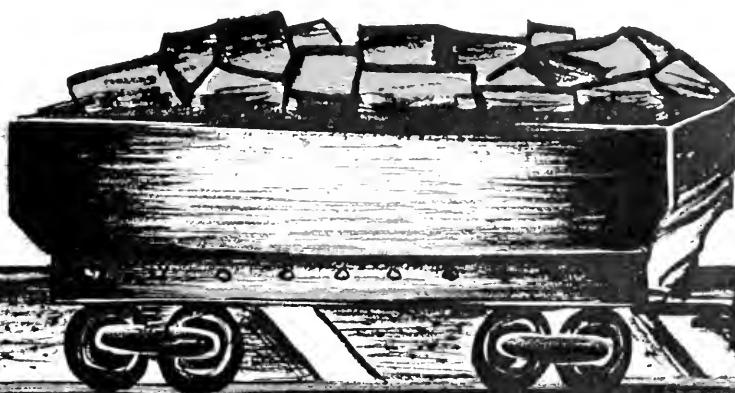
The operators of most machines sit where they can see what they are doing, or where they can get signals from helpers. But there is one that does things in a new way. Its operator just watches television in his cab. He never sees the parts of his machine at work. Instead, he



looks at the television screen. A television camera on the roof of the building photographs what is going on below. This is what the eye of the camera sees: One machine that gathers up pieces of scrap metal and dumps them into a squeezer; the squeezer that presses the scraps into neat bundles; a conveyor that loads the bundles into a railroad car.

The operator watches the moving picture. Then he pushes levers that control the loaders and other levers that send a car on its way when it is full. The only thing he can't do is switch on a regular TV program and watch a show while he works!

The time may come when people who operate other kinds of machines will find television helpful in many ways. Meantime, scientists who know how television works also know how to make the most wonderful machines of all. Instead of saving muscle-power, these machines save brain-power. They solve very complicated mathematical problems at lightning speed. In



fact, they are called "thinking machines." They add, subtract, multiply, divide and do figuring that many college professors can't even do.

Partly for fun, and partly to discover new things, the thinking-machine experts have also invented mechanical animals. They've made turtles that can walk all around a room without bumping into anything. They've made a little wire-whiskered mechanical mouse that can actually sniff about until it finds something it is supposed to find — just the way a real mouse sniffs out a piece of cheese. The machine-mouse even "remembers" where it went, and it runs straight to its cheese the next time.

The machines you've read about in this book are mostly outdoor machines, operated by one man or a small crew of men. These are only a few of the marvellous inventions that you can find at work every day. Of course, there are hundreds and thousands of others in factories, making cloth, shaping automobile parts, printing books, doing the important work the world needs done. But, no matter how marvellous and complicated they are, they will never be as wonderful as the men who have invented them and built them and used them. When we talk about machines, we're really talking about people.

FUNNY NAMES

Some machines resemble animals in the way they look or the things they do, and so they have animal names. Besides the caterpillar with its crawler treads and the crane with its long neck, here are some others:

ALLIGATOR GRAB — a tool used to pick up things that get dropped into oil well holes.

CAMEL-BACK CRANE — this one has a hump in its boom.

FISHTAIL BIT — a drilling tool which is shaped like a fish's tail.

KANGAROO PLOW — a plow equipped with strong springs so it can hop over rocks or tree stumps, instead of getting caught on them.

SHEEP'S FOOT TAMPER — a heavy road roller with spikes that pack earth down, the way a flock of sheep does.

WORM LOADER — a long screw that twists round and round to push its load along.



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